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MACHINE WITH LENTICULAR ROTATING PISTONS AND VALVES
[Maschine mit linsenförmigen Drehkolben und -ventilen]

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The invention concerns a machine with lenticular rotating pistons and valves for use with engines with inside and outside combustion chambers, expansion engines, and pumps.

In particular, the invention refers to a machine in which all of the movable parts carry out precisely circular movements around stationary points and whose work surfaces are in interrupted contact, among one another, according to a principle of analytical geometry. This machine is used in numerous areas of modern technology–in all motors with internal and external combustion chambers, i.e. in internal combustion engines and power engines with heat supplied from the outside, with compressors, with vacuum pumps, with blowers, with fluid flow engines, and with liquid pumps. /2*

In the known internal combustion engines, the chemical energy of the propellant is converted into mechanical energy with the aid of the classical systems of piston-connecting rod-crankshaft. The disadvantages of these machines are known: a considerable number of parts are moved, which makes production expensive, and the output of the machine is noticeably reduced. Furthermore, as a result of the short combustion time, which makes possible this system, a large number of environmentally polluting products are produced, especially if the machine runs at high speeds. One of the problems with engines with an internal combustion chamber in which spark plugs are used consists, as is known, in that the combustion process is insufficient and that a large part of the propellant entering the combustion chamber exits through the exhaust without being burned.

Furthermore, rotary engines are known, which are based on the principle of centrifugal pumps, and traditional slotted pistons, which carry out a longitudinal movement and a rotary movement, reciprocating circular movement engines, and engines with triangular pistons, which move without epitrochoid areas. All these engines have the advantage of an incomplete combustion and expansion.

* [Numbers in right margin indicate pagination of the original text.]

A known machine (US-PS 2 794 429) has, as movable parts, two essentially unequal oval runners, which turn in the same direction at the same speed, without coming into contact with one another or with the walls which partially surround them at any time.

These runners rotate according to the principle of turbine blades–that is, without any contact, so a /3 suitable compression is impossible and, moreover, for the operation, a blower at the inlet and a turbine at the outlet are needed, in order to utilize the great pressure and the high temperature at which the exhaust gases are conducted outwards. As a result of this complicated structure, a considerable construction and operation outlay is required.

In accordance with the invention, these disadvantages are to be eliminated by the creation of an engine with an internal combustion chamber, in which the conditions under which the combustion takes place are improved in that the combustion is carried out in a hermetically closed chamber with a constant volume–with ignition with a glow rod, which continues to glow during the operation of the pertinent engine, which is used instead of the intermittent spark plug, and which makes possible a complete combustion of the mixture at the highest speeds. The carrying out of the other compression and expansion processes in absolutely tight chambers with a variable volume, and the introduction of improvements, such as afterburning with complete energy utilization, automatic control of the combustion temperature, and complete expansion of the gases, so that a muffler is not required, bring about a substantial increase in the thermal output.

In a machine with substantially simplified components, all aforementioned advantages lead to exhaust gases which are practically free of environmentally polluting products.

The engine, in accordance with the invention, with an internal combustion chamber and with a constant volume, is to be small and have the same characteristics as the engine described in the

preceding, but function with normal expansion and without afterburning. This substantially simplified model with air cooling, low weight, and low volume is suitable as a low output drive motor for light /4 vehicles, such as boats, scooters, motorcycles, and the like.

In spite of the indisputable advantages of turbine jet propulsion units and TP engines at great heights and great speeds, which provide extremely strong engines with relatively low weight and low frontal surface, the use of reciprocating engines in aviation was not given up–mainly because of their great thermal output in comparison to the preceding. As is known, an engine with reciprocatingly operating pistons can never run as gently as a completely adjusted rotating mechanism nor can it attain speeds which would be comparable with those of turbines. Furthermore, it is known that the output released by any heat engine is essentially dependent on the maximum quantity of air which can be used. In aviation, reciprocating engines are still advantageous because they handle relatively small volumes under a high pressure and at a high temperature, whereas the turbines are preferred because of their great organic output and the great throughflow cross sections with large volumes and low pressures.

In accordance with the invention, therefore, an engine is to be created for aviation that can handle large quantities of air under a high pressure and at a high temperature–with constant flow, with practically continuous combustion and at very high speeds, without the slightest vibrations. This engine has a double effect.

The stresses are balanced in such a way that lateral forces which have the tendency to deform the shaft and to additionally load the shaft bearings are avoided. The engine is air-cooled and works with /5 a large of number propellants without making any noise. It offers weight-output-volume ratios which are better than those of TP engines. Such an engine makes possible greater propellant savings. Such an engine makes possible greater propellant savings than the reciprocating engines and various units can be mounted on the same axle.

Furthermore, engines with heat supply from the outside or engines with an external combustion chamber are known. A gas is thereby used in a hermetically closed circulation, which, when it expands, moves the alternatingly operating pistons, which transfer the force onto the output shaft–via the traditional connecting rod-crankshaft mechanism or with the aid of complicated mechanisms, such as oscillating disks or diamond-shaped carriers. The gas enclosed in the warmest part expands and escapes back to the colder area, wherein it stores heat in an intermediate regenerator. While flowing back to the expansion zone, it absorbs this heat once again and begins the cycle from the beginning. The combustion takes place outside the cylinder continuously–in suitable burners and with corresponding air, wherein the production of environmentally polluting products is noticeably reduced. This conversion of heat energy into mechanical energy, however, is impaired as a result of the insufficient output of these machines, which have the disadvantage that they operate in a reciprocating manner and furthermore, must overcome the friction forces that are produced by the numerous close outputs that constantly hinder the displacement of the gas.

In accordance with the invention, therefore, an engine with heat supplied from the outside is to be /6 created, in which the heat energy, including sun and nuclear energy, produced by an arbitrary medium, is converted into mechanical movement energy. The disadvantages of the traditional system are thereby avoided, in that the fuel is moved in a single rotating direction, in which a six-stroke cycle takes place. This cycle takes place with a half rotation–that is, the engine works with two cycles and produces symmetrical forces, which exert a balancing effect on the output shaft, so that the machine is completely balanced. As a result of its special conception, this engine offers the possibility to implement a system with a maximum sealing.

A pump is an apparatus with which a liquid can be continuously lifted, suctioned off, compressed, or suctioned in with the aid of mechanical or other means. Such apparatuses are compressors, vacuum

pumps, blowers, and various liquid pumps. These devices can be essentially summarized in two large groups–namely, pumps with forcible displacement and pumps with nonforcible displacement. In the first group are the volumetric pumps, which are designed as piston pumps or rotary pumps. Very generally considered, they are mechanisms which change the energy of the liquid, in that they increase the pressure, wherein the dynamic effect of the pertinent liquid is without significance. In the second group belong, essentially, the centrifugal pumps and the pumps with screw rotors and axial pumps, which convert the movement energy of the liquid into pressure energy. In accordance with the invention, the basic characteristics of the two aforementioned pump groups should be united in a single pump.

The pump in accordance with the invention is supposed to change the energy of the liquid by /7
increasing its pressure–by a volume change which corresponds to the displacement of the mechanical part–which transfers the drive energy and, at the same time, is supposed to convert the kinetic energy of this liquid into pressure energy. A new characteristic of the planned pump is its imbalance-free mode of operation, which is attained in that symmetrical forces produced in opposite chambers act on the shaft, so that lateral stresses of the bearings are avoided. Such a pump has the advantages of the two aforementioned pump groups, without subsuming their disadvantages.

Expansion engines, which are driven with air or vapor, work in numerous areas with reciprocating pistons or with sliding blades. In accordance with the invention, an expansion engine is to be created, which is an improvement of the known machines, because it receives the liquid in suitable quantities with constant volume and conducts it completely to a mechanical rotating element, so that a maximum output capacity is attained. In this machine, the lateral forces are also balanced, so that there are no deformations of the shaft, wherein vibrations are generated and the bearings could be additionally burdened.

A method for the geometric manufacturing of the profiles of the rotors also belongs to the invention; the rotors are connected with one another via the same circumferential arc, which is, in turn, once again determined by two other rectangular circumferential arcs that are arbitrarily selected.

With the aid of the appended drawings, the invention is explained by way of example. The figures show the following:

Figures 1-12: in graphic representation, the principle which is the basis of the invention; /8

Figure 13: an application of the principle of Figures 1-12;

Figure 14: a perspective view of a piston rotor;

Figure 15: a sealing strip of the piston rotor;

Figure 16: the piston rotor with canals;

Figure 17: a simple valve rotor;

Figure 18: a valve rotor for use in an internal combustion engine;

Figure 19: a movement diagram of the sliding surface alternation;

Figure 19a: a second movement diagram of the rotors;

Figure 19b: a third movement diagram of the rotors;

Figure 20: the combustion chamber, in cross-section;

Figure 21: a side view of an embodiment of the machine;

Figure 22: a schematic view of the machine of Figure 21, from the front;

Figure 22a: a side view of the machine designed as an internal combustion engine, with complete expansion;

Figure 23: the engine of Figure 22a, exploded view;

Figure 24: a section along the line A-A of the engine of Figure 22a; /9

Figure 25: a section along the line B-B of the engine of Figure 22a:

Figure 26: a section along the line C-C of the engine of Figure 22a:

Figures 27-41: the mode of operation of the engine of Figures 22a-26;

Figure 42: a side view of another embodiment of an engine working as an internal combustion engine, with normal expansion;

Figure 43: a section along the line D-D of Figure 42;

Figure 44: the five-stroke process of the engine in a p,V diagram, with normal expansion;

Figure 45: the five-stroke process of the engine in a p,V diagram, with complete expansion;

Figure 46: the structure of an engine, similar to Figure 22, but with heat supply from the outside;

Figures 47-56: the mode of operation of the engine of Figure 46;

Figure 57: a p,V diagram of the six-stroke process of the engine of Figure 46;

Figure 58: a T,s diagram (temperature, entropy) of the six-stroke process of the engine of Figure 46;

Figure 59: a schematic view of a liquid motor; /10

Figure 59a: a schematic view of a volumetric pump;

Figure 60: a schematic view of a pump with mixed displacement;

Figure 60a-60f: the mode of operation of the pump with mixed displacement in accordance with Figure 60;

Figure 61: a perspective view of an airplane engine in the form of an internal combustion engine;

Figure 61a: the compressor part of the airplane engine of Figure 61, in sectional view;

Figure 61b: the engine part of the airplane engine of Figure 61, in sectional view;

Figure 61c: the expansion part of the airplane engine of Figure 61, in sectional view;

Figure 62: a schematic view of the geometric structure of the lenticular profiles; and

Figure 62a: a schematic view of the geometric structure of the lenticular profiles, in general.

All of the aforementioned machines and those explained in more detail below are essentially based on the practical application of the following principle:

"If one rotates two rectangular circumferences in the same direction and at the same angular speed, then the most extreme points of their vertical diameters alternatingly describe four arcs, which form /11 lenticular figures which are perpendicular to one another and which turn uniformly and are always in contact with one another."

Figure 1 to Figure 12 show the production process of the lenses with the same movements. Three parameters are thereby given: the larger radius "R"; the smaller radius "r"; and the distance between the centers "a." The process takes place in the following manner:

Figure 1: The starting position of the two rectangular circumferences is shown on one plane, wherein the vertical diameters are the straight lines 1-1' and 2-2'.

Figures 2 and 3: A point 1 of the circumference I describes an arc on the circle II and forms a curve with the radius "a."

Figures 4, 5, and 6: A point 2' of the circumference II then describes, on the circle I, another arc with the radius "a."

Figures 7, 8, and 9: Another point 1' of the circumference I then describes another arc with the radius "a" on the circle II, so that a lens is formed.

Figures 10, 11, and 12: Point 2 of the circumference I then completes, with another arc with radius "a," the other lens on the circle I.

Figure 13: Here, an expansion of the principle is shown–that is, the possibility of repeating the coupling of various smaller lenses onto a larger one.

Figures 21 and 22 illustrate the general structure of the machine in accordance with the invention. /12
It consists of an apparatus which works cyclically with compressible fluids and is in a position of suctioning in specific quantities of this fluid, to compress them and move them internally, and to supply them with heat or remove heat from them, and which can expand and expel this heat or once again to make the heat circulate at arbitrary intervals, so that the fluid is exposed to thermodynamic processes. If this machine works with a noncompressible liquid, it is able to suction this in, to increase its pressure, to once again circulate and expel it. In all cases, the entry openings (not shown) to the machine can be arranged on the periphery. The machine can have annular entry openings, which are arranged around the shaft 65, if the rotor 70 is replaced by the expulsion rotor 71, which can be seen in Figure 16. The (not shown) exit openings can also be arranged on the periphery, as will explained later.

In Figure 22 and the following figures, 88 designates a stator with a middle recess, which is formed by the interface of various carefully processed cylindrical surfaces 89 and lateral plane surfaces 90, on which the side bodies 91 and 92, shown in Figure 21, are placed in the boreholes 93 with the aid of pins.

In contact with the cylindrical surfaces 89 and the presented covers 91 and 92, numerous lenticular rotors 70 and 72 rotate on the rigid axles 65 and 73, which are distributed in the manner shown in Figure 22. This large number of lenticular rotors form the movable parts of the machine and synchronize their movements with the aid of the outside gear 94, Figure 21, Figure 26, so that they rotate in the same direction and at the same angular speed–in complete kinematic interaction, as described with the aid of /13
Figures 1-12. The aforementioned rotors 70 and 72, which rotate in the same direction, move the fuel in the direction indicated by the arrows and transport it continuously from one chamber to the other, so that the sealed-off volumes, shown by A, B, C, D, E, F, G, and H, change their dimensions, whereas they move around the larger rotor 70.

If one arranges the entry and exit openings in an arbitrary manner, then the machine can cyclically suction in, transport, and expel a liquid.

Each of the main components of this machine is described in detail below. The rotor piston 70 (Figure 14) consists of a single piece, which is dynamically balanced, has a lenticular cross-section, and is composed of two cylindrical surfaces 71a, which are designed in accordance with Figures 1-12 and have plane sides, relative to one another. This rotor 70 has canals to hold the sealing strips 66 and the arc segments 68 on all its edges. The sealing strip, which is shown in detail in Figure 15, consists of two cone-like lamellae, which are arranged in such a manner that they form a plate of plane surfaces with an upper cylindrical friction border. A thin oil film must float between the planes; it facilitates the relative movement between the parts, which, in this way, exert a closure function on three sides and, at the same time, lubricate the friction surfaces.

The leaf spring 66' ensures that there is a sufficient pressure maintained between the closure and the surface 89 and makes possible a relative movement toward the groove 63. The arc segment 68, pushed forward from the selected spring 67 (Figure 14), rubs on the insides of the side covers 91 and 92 /14
with its planar side and its curved side follows the profile of the rotor 70. The sealing strips 79 of the valve rotors 72 contact it during the operation.

Via the plane sides of the rotor piston 70, the rings 69 mesh on springs on the base of the canals arranged concentrically around the shaft 65, where the energy that the machine receives or releases enters or exits. All segments 68, rings 69, and sealing strips 66 belong to the sealing system which is required to hermetically seal off the variable chambers in which the fuel is processed.

The variant of the piston rotor 70 shown in Figure 16 consists of a driven piston rotor 71 with inner conduits 74, in the form of spiral-shaped boxes or symmetrical screw spirals, which impart to the

aforementioned piston rotor an additional drive function, if the machine works as a displacement pump. This mode of operation will be explained later.

The valve rotor 72, shown in Figure 17, consists of one piece, which has two cylindrical surfaces 71-a-y, and which is closed off, laterally, by two planar surfaces. All edges have grooves which are used to hold the sealing strips 79 with the springs 80 and the arc segments 77 with the springs 78.

If this valve rotor works in the combustion chamber, it is provided with two cylindrical side disks 81 (Figure 18). These disks have canals 85 on their edges, which carry circular segments 84, which are made and operate in a manner similar to the segments 68. Rings 82 are set on the side disks 81; they are advanced by the springs from the bottom of the canal 83 (Figure 20). The valve 86 (Figures 18 and 20) consists of one single piece, which is dynamically balanced, and has a large number of inner canals– /15
namely, axial canals 87a and radial canals 87b and 87c (Figure 25), which bring about a cooling and lubricating oil circulation on the rings and segments. The shaft 87, which sits on suitable bearings, serves as a means to produce movement synchronization with the gear 94. Both the segments 84 and also the rings 82 rub on the cylindrical surfaces 105 in the side covers 99 and 104, which form extensions of the surfaces 89, as can be seen from Figure 23.

Figure 19 shows a sectional representation of the combustion chamber and reveals a movement detail of the alternation of the sliding surfaces between the sealing strips of the rotors. The arrows a, b, c, and d show how the curved surface of the piston rotor 70 presses against the sealing strip 79, when it approaches the vertex K, in order to alternate the sliding surface. From this point on, the sealing strip 66 slides over the bent surface of the valve rotor. This surface then pushes the sealing strip 66, as arrows e and f show, so that the surface alternation can take place at point K'.

On the hood of the combustion chamber, one can see the ignition device 103 in cross-section. Furthermore, the ceramic capsule 103' is shown, which embraces the heating wire 103", which is bent

back slightly, so as to avoid friction with the sealing strip 79. This heating filament 103" is an electrode, which glows constantly and can bring about the complete ignition of the mixture driven past by the valve rotor.

Figure 20 shows a longitudinal section of the ignition device 103.

Figure 19a shows a double lens combination, in which each rotor has a specific angular displacement between the main axes of its plan surface; this shift brings about a distortion of the curved planes, so that the apical edge or the vertex edges assume an inclination toward the with respect to the cylindrical /16
surfaces of the stator or housing.

This construction embodiment, in which the sealing strips are simplified with very thin friction lamellae, gives the rotors a spiral form and brings a substantial improvement to the transition of the sealing strip from the nonmovable surfaces of the stator to the movable surfaces of the rotors and the entry of the sealing strip from the curved movable surfaces of the rotors into the nonmovable cylindrical surfaces of the stator. This transition takes place gently and noiselessly and without the slightest possibility of an appearance of shocks. In this way, the machines in accordance with the invention can attain speeds of above 10,000 rpm.

The spiral rotor pair works in such a manner that each part, lying parallel to the planar surfaces, always forms two lenticular figures, perpendicular to one another, on each site.

Figure 19b shows three positions of the interacting rotors. In position A, the sealing strip of the larger rotor slides over the curved surface of the smaller rotor. In position B, the simultaneous movement of the sealing strips of both rotors is shown, which takes place when the transition from one surface to the other occurs. The sealing of the smaller rotor protrudes from the cylindrical surface of the stator at this moment and also is supported on the curved surface of the larger rotor–that is, moves from the

nonmovable surface to the movable surface. The larger rotor, on the other hand, moves from the movable surface to the nonmovable. The drawing shows how it temporarily lies on both surfaces.

In position D, the shift of the sealing of the small rotor is shown on the curved surface of the larger /17
rotor on the bending site.

If, in the machine of Figure 22, illustrating the basic principle, the lower valve 72 is left off, so that one has two parallel bodies with piston rotors on one and the same shaft, and if one distributes the entry and exit openings accordingly, then one obtains an internal combustion engine with constant volume and double expansion and afterburning after the first expansion (Figure 23).

This engine works practically without a separation of polluting gases. This is attained in that the mixture is completely burned in a rotating chamber with constant volume–with a combustion time which can be stipulated as a planning parameter. The pressure values attained in this chamber can be very high and be able to reduce the effects of the separation of the combustion-caused components CO_2 and H_2O. By having some of the gases of the first expansion automatically return, once again, to the aforementioned chamber, the combustion temperature is reduced and less nitrogen oxide is formed.

Furthermore, this engine has another low temperature-combustion chamber, which works according to the principle of the thermal reaction, and without a supply of NO_X, eliminates any residues.

One of the characteristics of the engine is a geometric design, according to which the output is quadrupled with a doubling of the stator diameter. The utilization of the available energy by attaining a complete expansion and omission of the muffler had not been attained up to now by a heat engine. Furthermore, coal dust and other residues do not accumulate in the interior of this engine and , /18
in theory, it works noiselessly with any propellant, wherein phenomena such as self-ignition and detonating combustion can be ruled out.

Figure 22a shows a side view of this engine. One can see the encapsuled design of its main parts and the sections A-A, B-B, C-C, will be explained in more detail later. Figure 23 gives a schematic representation of the main parts, excluding the shaft 65 and the cooling devices.

Part 91a forms a cover with inner conduits (not shown) for the circulation of the cooling and lubricating means and with suitable recesses to hold the bearings of the shaft and with a front outlet, in the form of a bent conduit 97, to hold the ventilator 95, which pushes out the exhaust gases. The intermediate part 99 consists of a separation space with parallel plane surfaces and friction traces 90a on both sides. Aside from the lubricating system, the cooling system, and the axle bearings, this separation space contains an air transfer tunnel, whose entry 101 allows the air from the entry chamber of the auxiliary piston rotor 70a to reach the compression chamber of the piston rotor 70. Under the entry 101, there is the exit 100 of the adiabatic tunnel, through which the gases from the pre-expansion chamber flow to the post-expansion chamber, under the piston rotor.

The sectional representation A-A (Figure 24) shows, in schematic form, the arrangement of the already explained movable parts and the entry opening 98 and the lateral opening 107, through which the cooling fresh air for the rotor 70a flows in, and again exits subsequently through the opening 107'. The drain valve 104 is adjusted by electrical pulses in such a manner that it is actuated at certain /19
time intervals. The goal of this valve is to regulate air the air or gas quantity conducted back to the combustion chamber and to the afterburning chamber.

Figure 25 shows, in section B-B, with a similar arrangement as in section A-A, the spray means 102 and ignition means 103, distributed on the combustion chamber. Furthermore, the combustion valve-rotor 86 is shown in Figure 25, wherein the axial cooling and lubricating tunnel 87a can be seen with the radial conduits 87c for the lubricating of the sealing strips 79. The peripheral conduit 106 shows

the axial circulation-cooling system. The synchronization system 94 is schematically shown in Figure 26.

The mode of operation of the previously described engine is explained, below, with the aid of Figures 27-41.

First, the auxiliary piston rotor 70a begins to produce the inner reduced pressure, which allows the air to flow in through the opening 98 (Figure 27).

The filling of the first entry chamber continues, whereas the opening 98 is gradually closed by the inlet valve 72a (Figure 28).

The gate value 72b opens the entry of the transfer tunnel 101, through which air flows to the compression chamber of the piston rotor 70 (Figure 29).

The inlet valve 72a has closed the opening 98. In this way, the first stroke, namely the supply, is ended. In this time interval, the cooling air enters through the lateral opening 107 and exits through the /20
opening 107' (Figure 30).

The auxiliary piston rotor has almost ended the transfer of the air, whereas the piston rotor 70 begins with the compression in the body 88b (Figure 31).

The arrow marks the part of the allowed-in air, which flows back, once again, via the gate valve, to the thermal reaction chamber for the afterburning of preceding cycle (Figure 32).

The piston rotor 70 then ends the second stroke, the compression (Figure 33).

Figure 34 shows a moment of the compression process, which is completed without a volume change, wherein the ignition mixture sweeps past the glow wire of the ignition device 103. This is a part of the third stroke, the combustion.

Now, the expansion acting on the piston rotor 70 begins (Figure 35).

The expansion comprises the entire piston rotor 70 (Figure 36) and also acts on the gate valve 72e, before it opens the adiabatic tunnel, whose entry opening is shown in Figure 37.

The hot gases enter through the adiabatic tunnel, which is drawn in, with a broken line, in the part 88b, and migrate to the afterburning chamber of the part 97, through the opening 100 (Figure 37).

The afterburning takes place immediately, with the rapid entering of the hot gas flow by means of an oxygen-enriched air mass (Figure 38).

The expansion continues to act on the rotor piston 70a, whereas hot gas from the part 88b, expelled /21
through the piston rotor 70, continues to flow (Figure 39).

In the phase shown in Figure 40, the expansion has already ceased and in the part 88b, the valve 72e retains the last part of the gases of the first expansion, which have already begun to cool off. This part of the gases expands under the piston rotor 70 and cools rapidly thereby, so that it serves as a coolant for the rotor. Subsequently, it is compressed and conducted behind the valve 72d, so as to then flow back to the combustion chamber, where it acts as an oxygen reducing agent to lower the combustion temperature. This phase represents the end of the fourth stroke, the expansion.

The auxiliary piston rotor 70a then discharges the waste products to the outside (the ventilator 95 is not shown) and thus ends the fifth stroke–namely, the exhaust (Figure 41).

On the basis of this machine, one obtains, with the arrangement shown in Figures 42 and 43, a greatly simplified engine with an internal combustion and constant volume, which essentially consists of a stator or block 88c, which is closed off on both sides by the parts 91c and 92c, which serve as a friction surface for the sealing strips 66 and 79 and for the segments 68 and 77 and for the rings 69 to seal off the compression chamber A, the combustion chamber B, and the expansion chamber C.

The mode of operation of this simplified engine with a normal expansion corresponds to that of the previously described engine with a complete expansion. Here, the piston rotor 70 suctions in an air mass, via the entry 109, begins with its compression in the chamber A and ends the compression in the /22 chamber B, where, with the aid of the ignition device 103, the combustion is introduced, which increases the pressure of the gases and brings about the rotary movement of the piston rotor 70. After the end of the expansion, it pushes the gases to the exit 110.

In diagrams, Figures 44 and 45 show the 5-stroke cycles with a coordinated pressure-volume system for the engines described above, with normal and complete expansion.

In a simplified schematic representation, Figure 46 shows a variant for operation as an engine with an external combustion space or as a combustion engine with heat supplied from the outside. Here, a gas heated by some medium (sun-energy furnace, or any burner, or a nuclear reactor) enters simultaneously through the two entry openings 111 placed symmetrically on the stator 88d. The gas is moved into the heat exchange chambers Q, circulates through the tunnel 112, and exits, once more, after the heat transfer through the exit openings 113 has ended. The rotors first moved by some device coupled with the exit opening are then set in rotation by the successive expansions of the tightly enclosed, inner gas, moving under high pressure. The cooling of the inner gas takes place in the counter-chambers P, which remove the heat by transfer into the cooling liquid, which circulates through the tunnel 115 from the entry 114 to the exit 116. For a better understanding of the thermodynamic process, which takes place in the inner gas (helium or hydrogen), the mode of operation is explained with the aid of Figures 47-56.

Figure 47 schematically shows the initial time when the greatly compressed inner gas is found under the same pressure in all the chambers. /23

Then, the heat supply begins (Figure 48). If the gas contained in the exchange chamber Q has reached the required temperature, the starting device is actuated. It begins the expansion with a movement in the system until it rapidly reaches several times the uniform pressures and speeds in the various chambers.

As Figure 49 shows, the gas then begins to expand at the maximum operating temperature and to act on the piston rotor 70 with the production of work. One notes the simultaneousness of the process in the opposing chambers.

The torque is produced by the action of the forces which arise as a result of the simultaneous expansion (Figure 50).

The expansion is completed and the compression toward the opposing chambers P begins (Figure 51).

Figure 52 shows that the gas is pushed toward the heat removal chamber P as it cools off.

In the heat removal chamber P, it is completely compressed, with considerable cooling, and its temperature continues to drop (Figure 53).

The cooling process takes place with a constant volume, whereas the temperature of the gas continues to drop (Figure 54).

A process (Figure 55) then takes place in which the gas expands and work is delivered, whereas its temperature still continues to drop.

The almost completely expanded gas, which has then attained its lowest temperature, now begins to /24
absorb heat already in the chamber Q and is prepared for the compression by the absorption of heat so as to repeat the cycle (Figure 56).

This entire process is shown in the p,V diagram of Figure 57. The square area represents the work released during the process and the broken-line area, the absorbed work. The areas represent the work thereby in mkp.

Figure 58 shows the process in the temperature-entropy diagram. The work is indicated in calories. Here too, the square area represents the output released by the process and the broken-line area, the absorbed output.

The strokes of the process are the following:

1-2 Heat supply with constant volume

2-3 Adiabatic expansion

3-4 Compressing with constant pressure

4-5 Heat release with constant volume

5-6 Adiabatic expansion

6-1 Compression with heat supply.

The preceding description refers to engines with internal and external combustion chambers. The field of application of the invention also extends, however, to steam- and compressed air-operated expansion engines, including hydraulic engines, with locomotion engines. Figure 59 shows, in schematic representation, a liquid engine, which is a modification of the machine in accordance with Figures 22-25.

The liquid engine or the expansion engine, shown in Figure 59, comprises the movable parts, which /25
have already been described in detail, and the stator and the covers, which are, however, used here in such a way that the chambers F, which lie symmetrically opposite one another, take up specific quantities of the engine fluid, under specific pressure, through the entry openings 117, at the time when these chambers maintain their volume constant. If the machine is not moving, then a slight angular shift causes the engine fluid to act on the piston rotor 70 and to make it rotate. After the liquid has released its energy, it once again exits through the openings 118. The stress of the shaft of the machine is compensated for by the effect of the opposing chambers H.

In a simplified schematic representation, Figure 59a shows the machine in a modification as a forcible displacement pump. This version is suitable for various application purposes, for example, as a compressor, vacuum pump, blower, and liquid and semi-liquid pump.

The pump shown in Figure 59a consists of a stator 88f with cooling ribs (for compressors and vacuum pumps) and with the inlet openings 119 and outlet openings 120 for the entry and exit of the liquids to be conveyed. The symmetrical chambers G always produce the back flow of some of the conveying medium (white arrows), as is the case with reciprocating machines with dead volume.

The mode of operation of the pump is simple. The one-sided dynamic effect (represented by black arrows in the drawing) of the liquid during the entry is thereby utilized, which is added up with the drive effect produced by the piston rotor 70. The machine has a double effect, wherein equal diametrical /26 forces act on the shaft 65.

Figure 60 shows a variant of the aforementioned pump, wherein the piston rotor 70 is replaced by the drive piston rotor 71, which has an annular suction part 121, which is connected with the internal chambers of the pump via the spiral tunnels 74.

The pump works in the following manner: Upon rotating the drive piston rotor 71, a vacuum–that is, a reduced pressure–is formed in the annular suction opening 121. The liquid enters axially as a result of this pressure difference and is then deflected radially when it flows through the spirals 74.

Figures 60a-60b illustrate the double function of the drive piston rotor. Figure 60a shows a state in which the pump housing begins to fill as a result of the rotation-dynamic effect of the drive piston rotor 71. With the drive piston rotor creating a vacuum with its rapid rotation, it suctions in the liquid and moves it via the spirals 74, wherein it imparts to the liquid particles such an acceleration that they assume the speed of the rotor and move parallel to it in the rotating direction shown in Figure 60b. The suctioned-in liquid converts its speed into pressure at the exit of the spirals. Figure 60c shows the

expulsion of the liquid through the symmetrical openings 120. Figure 60d, 60e, and 60f show the piston rotor 71 as it increases the pressure of the liquid merely as a result of the volumetric effect.

With this pump, there is, in addition to this double effect, the system of the compensated stress also, which results from the double symmetry and which also produces a practical constant relief.

This working principle, which is based on the fact that parts are used, which carry out a pure rotating /27 movement at a very high speed and are made in such a way that they can create an infinite number of pressure conditions and, furthermore, are able to work with such a compensation and adjustment that the main rotor behaves like a flywheel, makes the device also suitable for the creation of very high pressures.

The embodiment of the machine shown in Figure 61 is an air-cooled engine with double effect, which is suitable for incorporation into the bearing surface of airplanes as a result of its structure.

As Figure 61 shows, this engine consists of three parts or stators 88h, 88j, and 88k of different thicknesses, which are separated from one another by the separating walls 127 and 129. The whole structure is closed off, from the front, by the cone body 91 h with the annular entry opening 124 and the propeller carrier 123. The cover 92h forms the back closure.

The first stator 88h, which works as a compressor, has, in its interior, the drive piston rotor 71 (Figure 61a), with axial suctioning 121 of the air coming from the annular entry opening 124. This drive piston rotor 71 compresses the suctioned-in air, in an interaction with the valve rotors 72; the air flows to the chambers A of the combustion stator 88j (Figure 61b) through the entry openings 101. The piston rotor 70 introduces the charge into the symmetrical combustion chambers B. After the combustion, there is a first expansion acting on the piston rotor 70. The gases exit through the openings 100a, cross the separation wall 129, and arrive at the part 88k, where they act on the expansion piston rotor 70a in the chambers L (Figure 61C) and are subsequently expelled through the exit conduits 132. All mentioned /28

rotors (70, 70a, and 71) are mounted on one and the same shaft 65 (Figure 61) and share the force via the turning of the screw 122, visible in the drawings.

Since the compression ratio is changeable as a function of the speeds of the engine and of the speed of the airplane, the propellant quantity supplied by the spray nozzles 102 (61b) varies, depending on the output requires for the most cost-efficient flying state.

The gases expand simultaneously into the chambers C, lying diametrically opposite one another, and produce a rigid torque on the piston rotor 70; not only lateral force effects on the bearings are thereby avoided, but the air in the opposite chambers C is also compressed, so that only the actual starting output acts via the shaft.

The gases acting on the piston rotor 70a by expansion have a similar effect and produce another strong torque on the engine shaft, which, as a result of its simultaneity, is added to the aforementioned torque on the piston rotor 70.

All embodiments of the machine in accordance with the invention are built on the basis of the geometric scheme shown in Figures 62 and 62a. Proceeding from two parameters–namely, the smaller radius r and the larger radius R of two rectangular surfaces–one obtains the relationship between the rotors 70 and 72, together with the inside surfaces 89 of the various stators used.

Figure 62 shows the fundamental geometric structure, based on this principle, in which two arbitrary /29 surfaces with the radiuses r and R and the centers 01 and 02 are selected, wherein the distance between the centers a is then determined according to the Pythagorean theorem.

With the center in 01, the circumference is marked in parts with the radius R and with the center in 02, the circumference is marked with the radius r. The intersection point of the two surfaces 03 is used as the center for an arc with the radius a within the original surfaces.

Subsequently, then, the 03 diametric, diametrically opposite points on each surface 03 and 03", are used as centers for two arcs with the radius a, which complete the two lenses.

The geometric structure of the combined lenses can be generalized to other lenses, as Figure 62a shows, wherein only the distance between the centers need be maintained, which now goes from point 02 to point 01'. On the diameters 04-04', lying parallel to 03-03", the arcs are marked with the radius a, which form the new lenses. In this way, one can create as many smaller lenses as is physically possible, corresponding to the ratio between r and R.

Claims /30

1. Machine with lenticular rotating pistons and valves for use in engines with internal and external combustion chambers, expansion engines, or pumps with a middle stator and two lateral bodies as covers, wherein, in the interior of the aforementioned stator, there is a large number or rotating elements, which are supported so they can rotate on nonmovable parallel axles; the supports are in the aforementioned covers; and the parallel axles are synchronized by a synchronization device, which synchronizes their rotational movements into the same direction and at the same angular speed, characterized in that the central stator (88) has a middle cylindrical recess (90), on the inside on its entire thickness, which is cut through coaxially by various smaller cylindrical surfaces (89), which are located, distributed on the periphery, at a distance from one another; in that within the middle cylindrical surface (90), a piston rotor (70) with a lenticular cross-section turns, which touches this central surface (90) with its vertices; in that the piston rotor (70) is surrounded by several valve rotors (72), which also have a lenticular cross-section and which rotate and thereby touch the aforementioned, smaller cylindrical surfaces (89); in that all rotors (70,72) have sealing elements (66,68;77,79) on all edges, and as a result of the profile of their lenticular surfaces, which are formed by a single circumferential radius, maintain the contact and the opposite sliding movement between their vertices and curvatures, so that they form /31
working chambers of changeable volumes, sealed off relative to one another, wherein so that the machine can work as a combustion engine, pump, or expansion engine, entry and exit openings, a fuel spraying, ignition, and cooling system are appropriately arranged.

2. Machine according to Claim 1 for use as an internal combustion engine with double expansion and afterburning, built up from 5 planar parts with different thicknesses, which are connected organically with one another via tunnels and various conduits, wherein a shaft goes through these parts and the main rotating pistons are coupled on the shaft and it moves the gear which unifies the mode of operation of all

movable parts of the engine, so that they rotate in the same direction and at the same angular speed, characterized in that the first planar part (91a) contains a friction surface, recesses to hold bearings, lubricating and cooling means, and a front outlet, to which a bent tube (97) is connected, through which the waste gases escape; in that the second part is a plane stator (88a) with peripheral air entry openings (107) and lubricating and cooling conduits, in whose inside, there is a middle recess (89) in the entire thickness, which is formed by four cylindrical surfaces which intersect one another, in which three valve rotors (72a,72b,72c) with sealing elements (77,79) on all edges rotate around an auxiliary piston rotor (70a), whose edges (66,68) are likewise all sealed off, so that hermetically closed-off chambers are formed with the aid of the third part (99), which consists of a separation wall with a number of inside conductors and indentations to hold bearings and rotating elements and is closed off by two plane sides, which serve as friction surfaces; in that the fourth part is a plane stator (88b), which is equipped with /32
additional fuel spraying devices (102), ignition devices (103), and outlet devices, and which has an inside recess, which is formed by four cylindrical surfaces, which intersect, in which three valve rotors (72d,72,72f) rotate around a main piston rotor (70); in that the four rotors have sealing elements (66,88;77,79) on all three edges, so that hermetically sealed-off chambers (A-H) are formed; and in that a cover (92a) forms the closure of the engine, in which indentations and inside recesses and various lubricating and cooling conduits are found.

3. Machine according to Claim 1 or 2, with three bodies organically connected with one another by tunnels and various conduits, through which a shaft is conducted axially and which is supported on the lateral coverings and with which a main rotating element and the synchronization device is connected, which unifies the rotational movement of all movable parts, characterized in that the stator (88c) with additional spray and ignition devices (102,103) has a general opening for the entry of the air (109) and the exit of the waste gases and a recess in its interior (89), which are formed by two cylindrical surfaces

with the same diameter, which mutually intersect and are arranged coaxially to form another middle cylindrical surface and in which two valve rotors (72) rotate, which are connected with the main piston rotor (70) in such a way that with the aid of the sealing elements (66,68;77,79), which are found on all edges in the aforementioned rotors, they form hermetic chambers with changeable volumes.

4. Machine according to Claim 1, for operation as an airplane engine with an internal combustion /33
chamber and double effect and double expansion, consisting of at least seven planar bodies, which are connected organically with one another and are so arranged that three stators with different thicknesses are separated by two bodies which form the separation walls, wherein the whole structure is closed off with a front cover, which carries the air screw, and a back cover, where the synchronization device is located and the movement is imparted by the shaft, which crosses the seven bodies, so that all movable parts of the machine carry out the same rotational movement, characterized in that the first stator (88h) is a planar body with cooling ribs on its entire periphery and an inside recess, which is formed by three intersecting, cylindrical surfaces, which are axially arranged, so that the valve rotors (72) therein rotate around a central piston rotor (71) and are in contact with it; in that the piston rotor (71) is a drive rotor with an annular suction opening (121), arranged around the axle, which makes possible a long-term suctioning of air; in that the middle stator (88) is provided with heat-removing cooling ribs on its periphery and with spray and ignition devices and has a recess in its interior, which is formed by five parallel, cylindrical surfaces, which intersect with one another, in which four valve rotors (72) rotate around a main piston rotor (70) and are in contact with it; and in that the third sector (88k) has cooling ribs [and] two exit openings (132), located on the periphery, and has a recess in its interior, which is formed by three parallel, cylindrical surfaces, which intersect with one another, in which two valve rotors (72) rotate around a central piston rotor (70) and are in contact with it, and wherein all rotors have /34
sealing elements (66,68;77,79) on their edges.

5. Machine according to Claim 1, for operation as an engine with heat supplied from the outside, with essentially three parts, organically connected with one another by tunnels and peripheral conduits, wherein the main body is a stator with a middle recess, which is hermetically closed by two lateral coverings, on which bearings and various auxiliary conduits can be accommodated, characterized in that the middle recess of the stator (88d) is formed by five cylindrical surfaces, which intersect in such a manner that an average cylindrical surface with a larger diameter is surrounded by four smaller surfaces which are found at a distance from one another, in which four valve rotors (72) move, which slide on the surfaces surrounding them and, furthermore, are in contact with a piston rotor (70), which rotates within the middle cylindrical surfaces, and with the aforementioned surfaces; in that the five rotors are formed by cylindrical surfaces of one and the same radius, and have sealing elements on all their edges, so that upon rotating with the aid of the inside walls of the stator (88d) form six dense chambers with variable volumes, which continually move around the piston rotor (70), while the aforementioned rotors (70, 72) rotate, with the same movement, in one and the same direction, and which act on the gas hermetically enclosed in these chambers; and in that the stator (88d) has a number of entry and exit conduits (111,113), through which the heat produced by some external medium and the cooling liquid continuously circulates.

6. Machine according to Claim 1, for operation as an expansion engine, consisting of three closed /35
parts, from which two lateral covers form, on which bearings and various lubricating means can be accommodated, characterized in that the stator (88e) has various entry and exit openings (117,118) for flowing fluids on its periphery, which are connected with an inside recess (89), which is formed by two intersecting, cylindrical surfaces with the same diameter, which are symmetrically arranged around a third middle cylindrical surface, which, in general, has a larger diameter; in that three rotors (70,72) with a lenticular cross-section are found within the three aforementioned parallel, cylindrical surfaces, whose

shape is formed by a single circular circumferences; and in that the rotors (70,72) are provided with sealing elements (66,68;77,79) on all edges and during their rotation on straight-line axles, form hermetically closed chambers with changeable volumes, in which the flowing fluid expands.

7. Machine according to Claim 1, for operation as a positive displacement pump, consisting of three closed bodies, wherein the main body is a stator and has suctioning and exit conduits, which are expediently located and connected with an inside recess, which extends over the entire width of the longitudinal axis, characterized in that the inside recess is formed by two intersecting, cylindrical surfaces with the same diameter, which are arranged symmetrically around a middle cylindrical surface, which, in general, has a larger diameter; in that within the three aforementioned surfaces, three rotors /36
(70,72) with a lenticular cross-section rotate, which is formed by one and the same circular circumference; and in that the rotors (70,72) are provided with sealing elements (66,68;77,79) on all their edges, so that upon rotation on straight-line axles, supported on the lateral covers closing the stator (88f), two chambers with changeable volumes are formed, in which the conveying medium is acted on.

8. Machine according to Claim 1, for operation as a mixed displacement pump, consisting of three closed bodies, wherein the middle body or stator is closed by two covers, on two sides, which contain the bearings and various lubricating conduits; the middle body or stator has two exit conduits for the flowing fluid to be processed; and the aforementioned conduits are connected with an inside central recess of the aforementioned stator of the pump, characterized in that the aforementioned recess (89) is formed by two intersecting, cylindrical surfaces with the same diameter, which are arranged symmetrically around a central cylindrical surface, which, in general, has a larger diameter; in that within the three aforementioned cylindrical surfaces, three rotors (70,72) with a lenticular cross-section rotate, which is formed by one and the same circular circumference; in that the rotors (70,72) have sealing elements (66,68;77,79) on all three edges; in that the piston rotor (70) rotates within the larger

cylindrical surface, has canals in the form of spirals (74), which are connected with the inside chambers of the stator (88g), and are connected, toward the outside, via an annular entry opening, which is located around the axle, wherein the annular entry opening also leads through one of the side coverings, so that /37 it forms the entry or suction opening of the pump.

9. Method for the production of a machine according to one of the preceding claims and, in particular, for the geometric construction of the curved profiles of the rotors connected with one another, characterized in that two arbitrary circular surfaces are selected, which intersect at right angles; and in that the aforementioned two circular surfaces are formed with broken lines in such a manner that the larger circular surface comes to lie on the smaller one with the continuous line, and the smaller broken line is located within the larger one with the continuous line; in that four arcs are drawn with the center in the intersection point of two circular surfaces with the broken line from the diametrically opposite points to the broken-line circular surfaces; their radius is equal to the distance between the centers, so that they form two lenticular figures in contact with one another via their peaks within the original circular surfaces; in that additional line pairs can be added to the drawn lens pair by repeating one lens; and in that an angular shift of the main axis of the lenses can be undertaken, so that spiral rotors with curved surfaces are formed.

Fig. 1

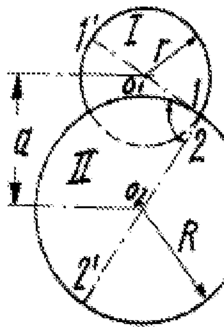


Fig. 2

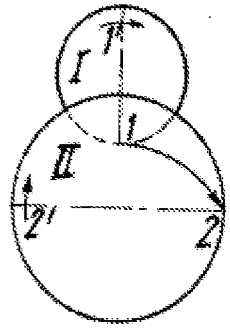


Fig. 3

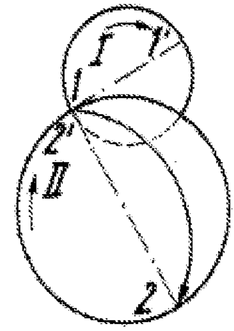


Fig. 4

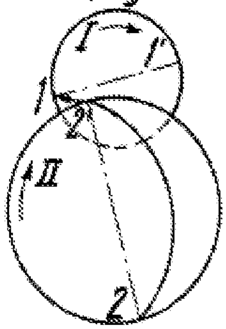


Fig. 5

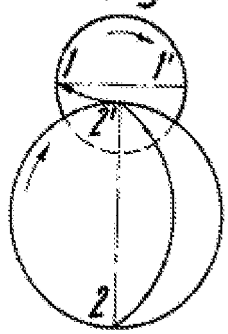


Fig. 6

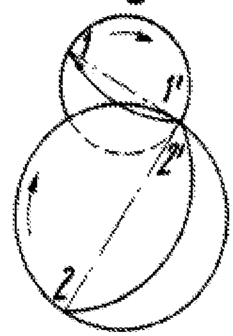


Fig. 7

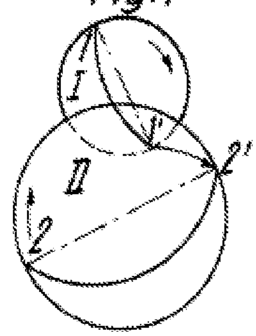


Fig. 8

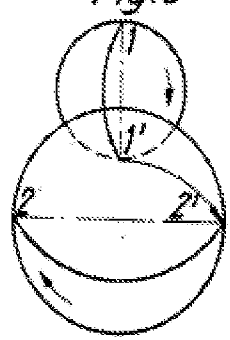


Fig. 9

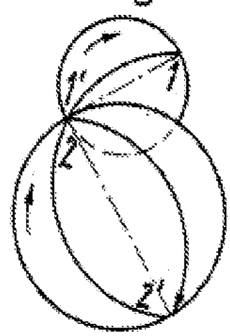


Fig. 10

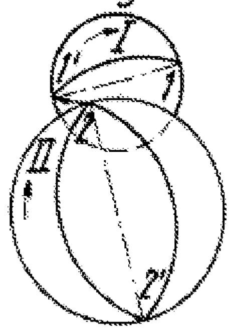


Fig. 11

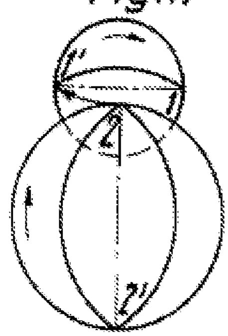


Fig. 12

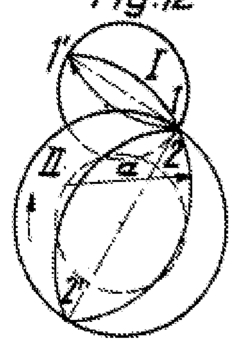


Fig.13

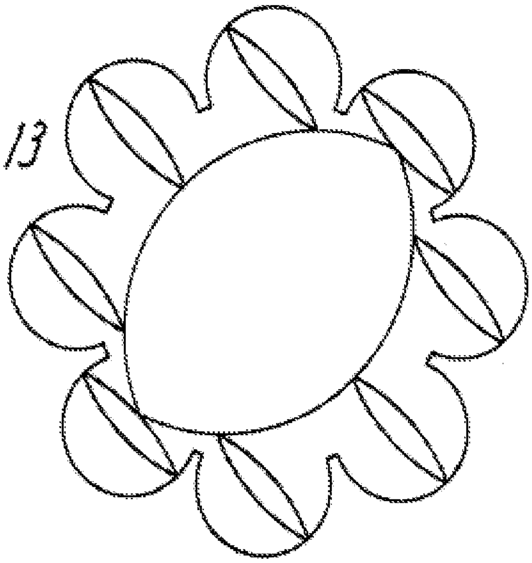


Fig.14

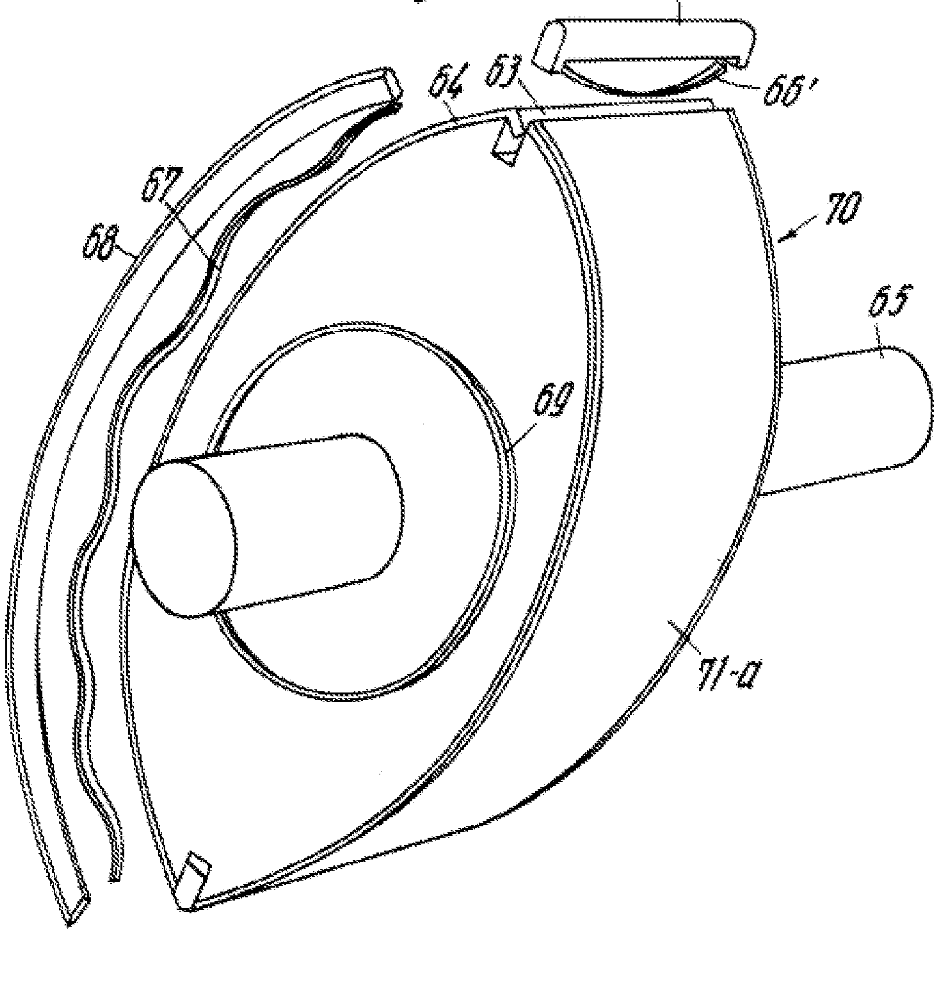


Fig. 15

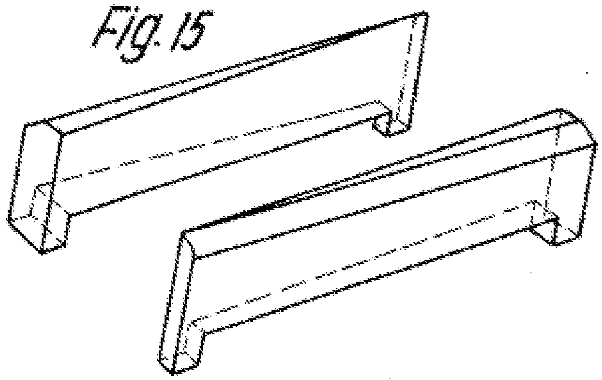


Fig. 16

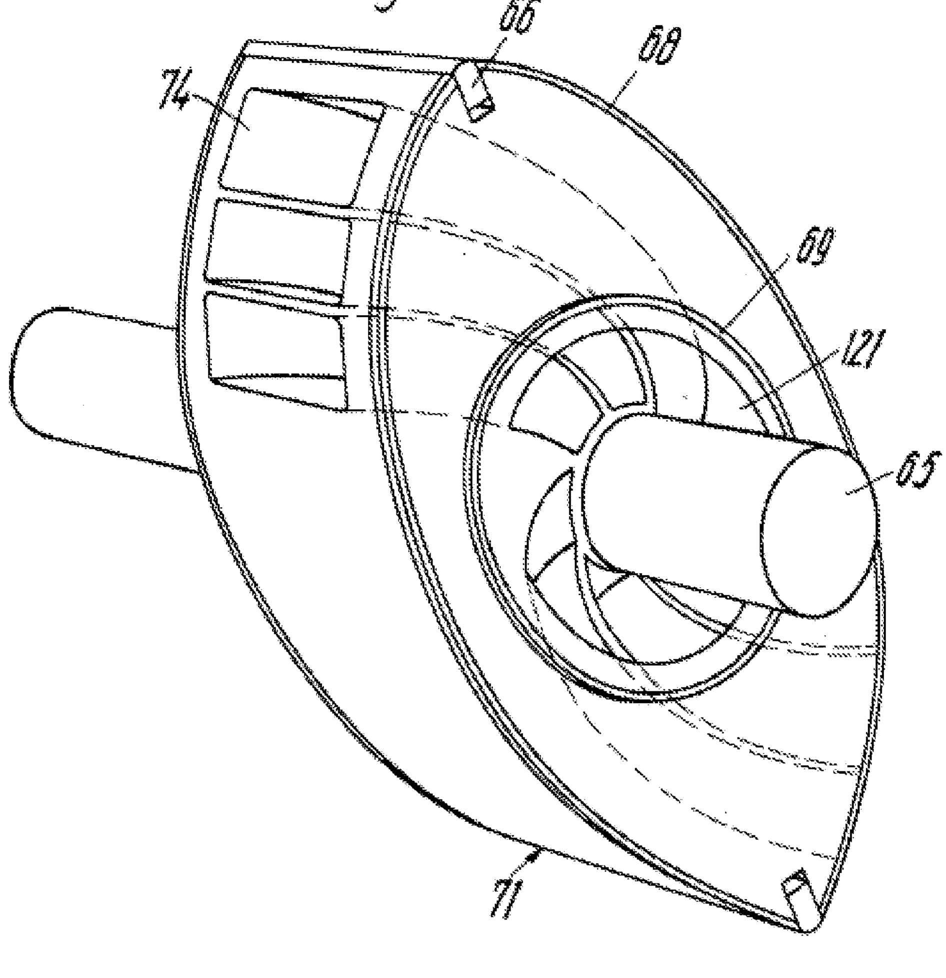


Fig. 17

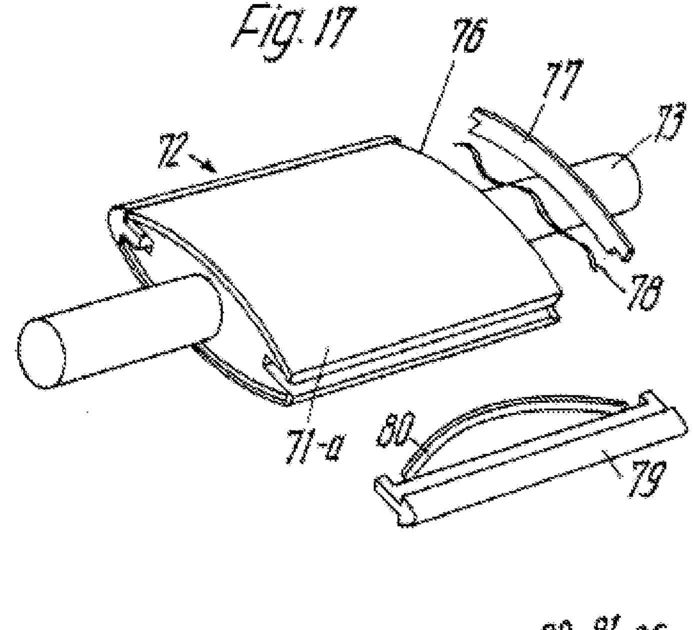


Fig. 18

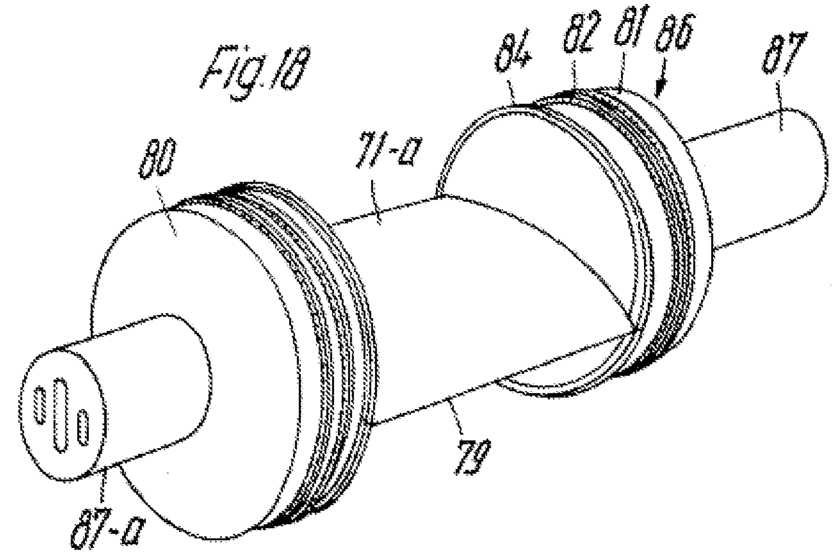


Fig. 19

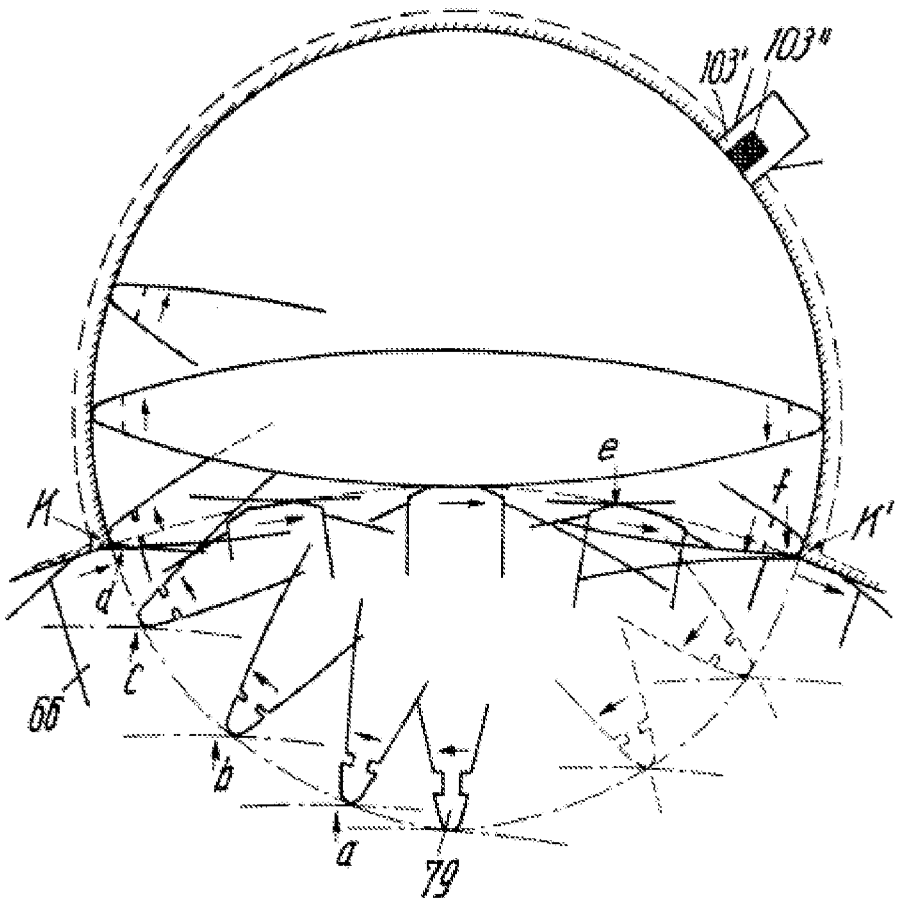


Fig. 19-a

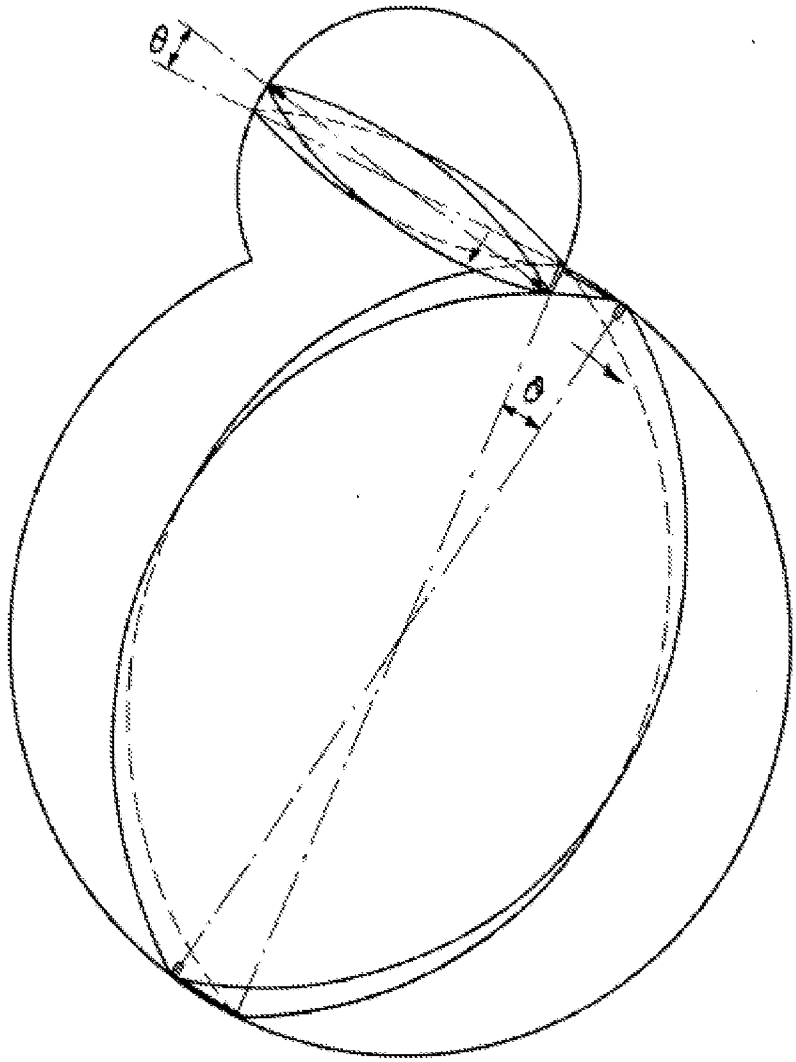


Fig. 19-b

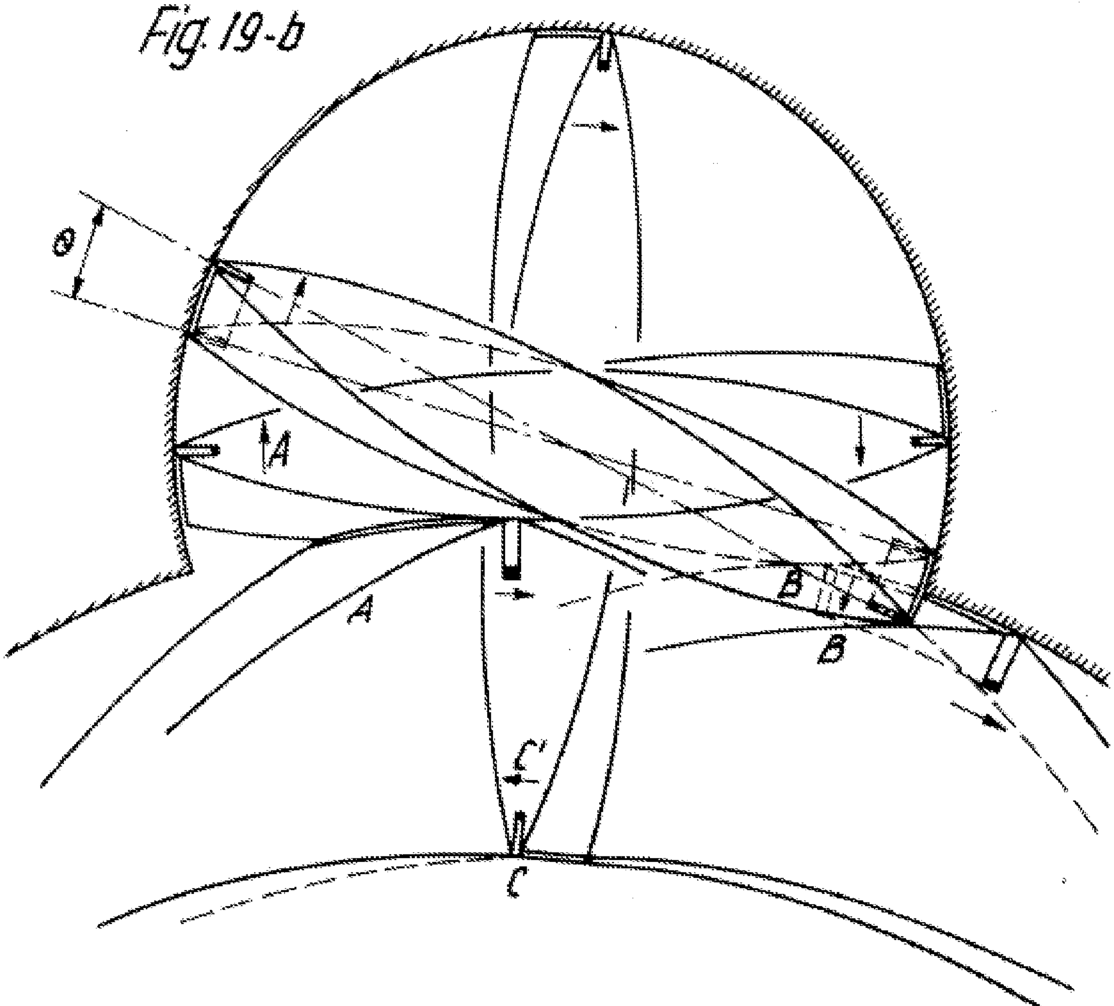
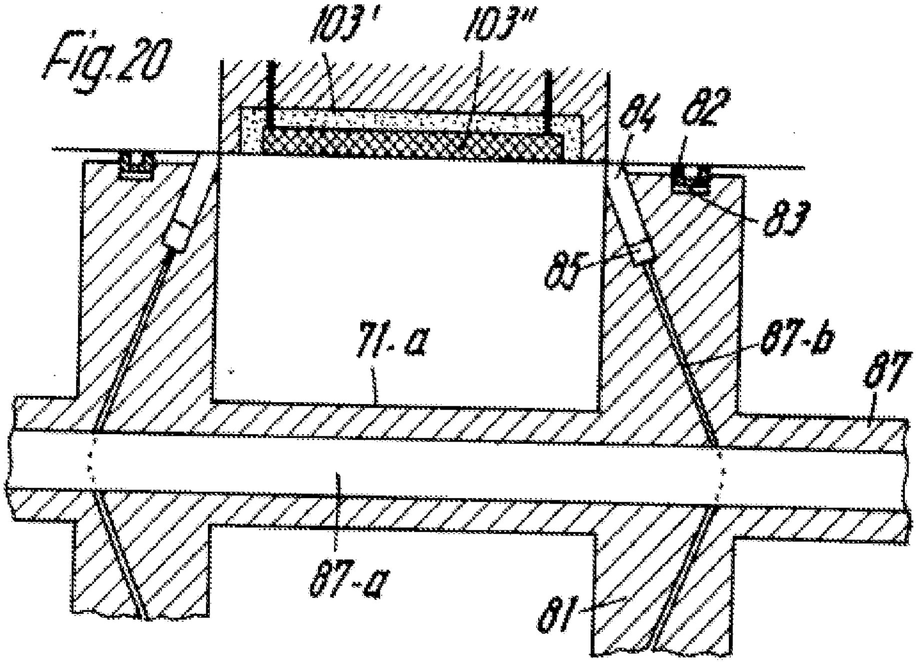


Fig. 20



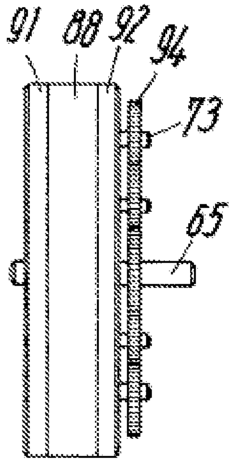

91
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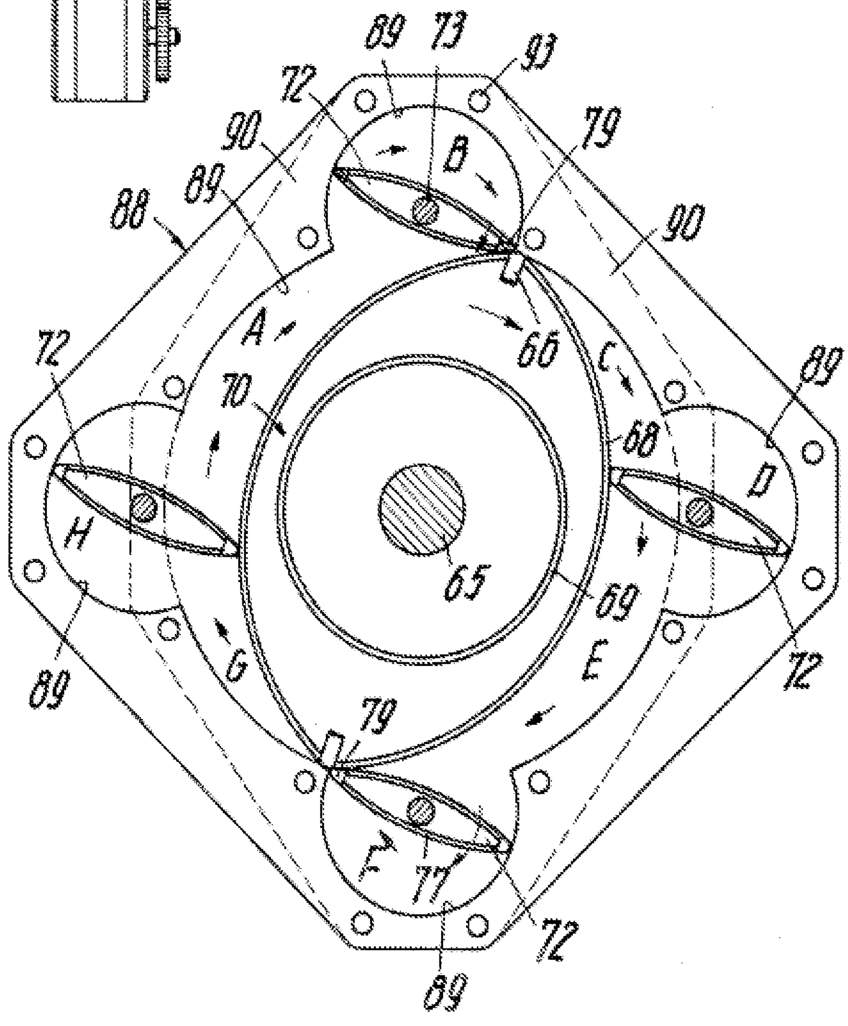
Fig.21

Fig.22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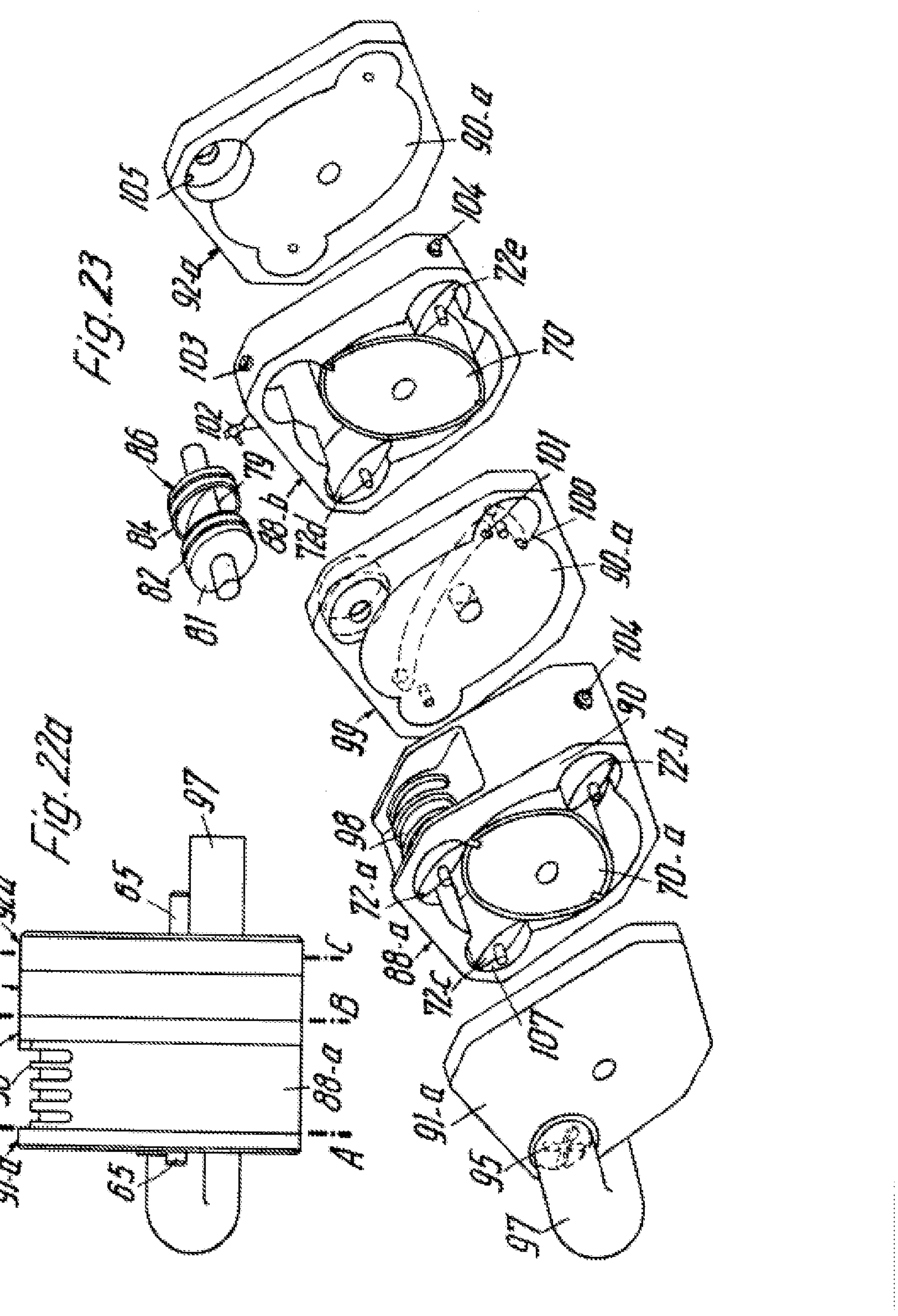


Fig.22a

Fig.23

Fig. 24
(A-A)

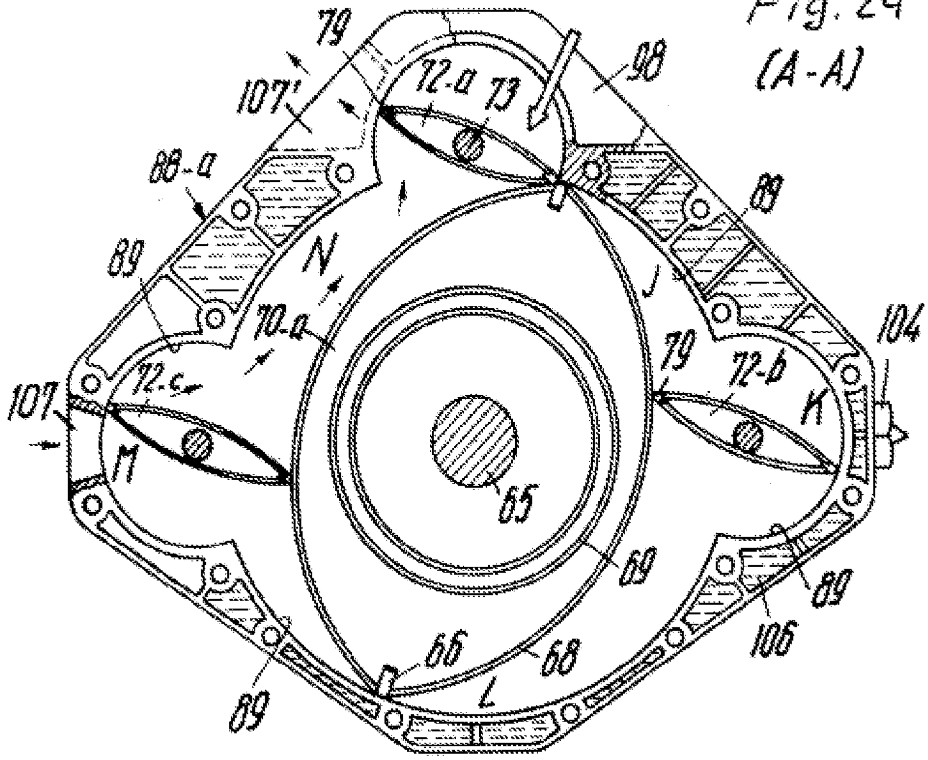


Fig.25
(B-B)

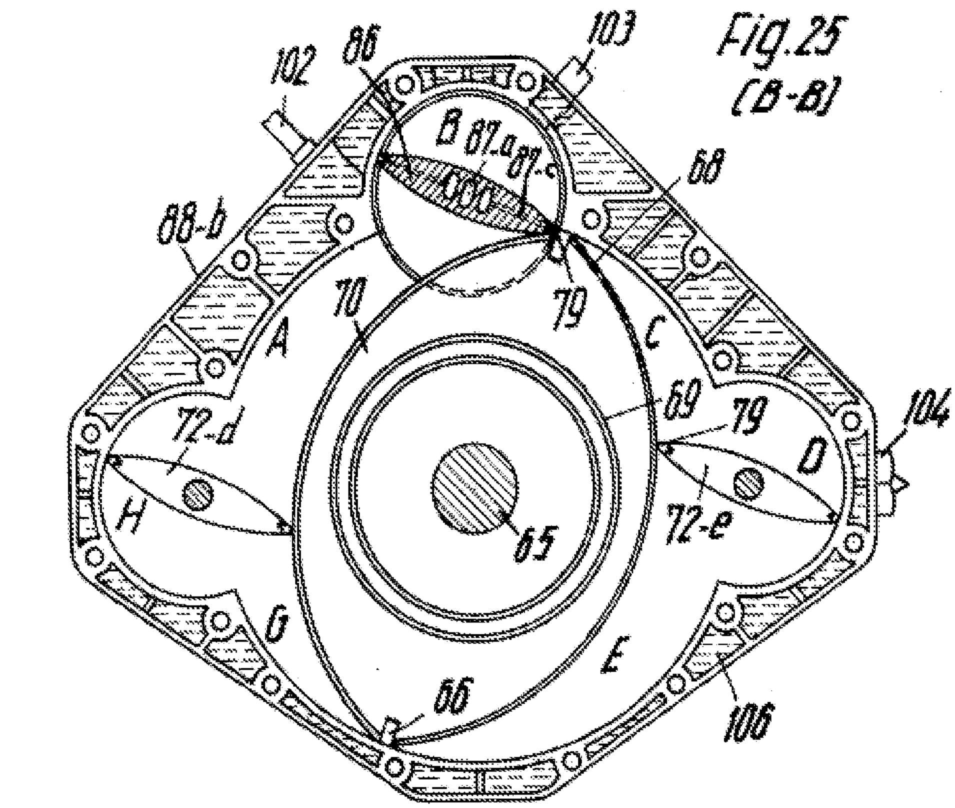
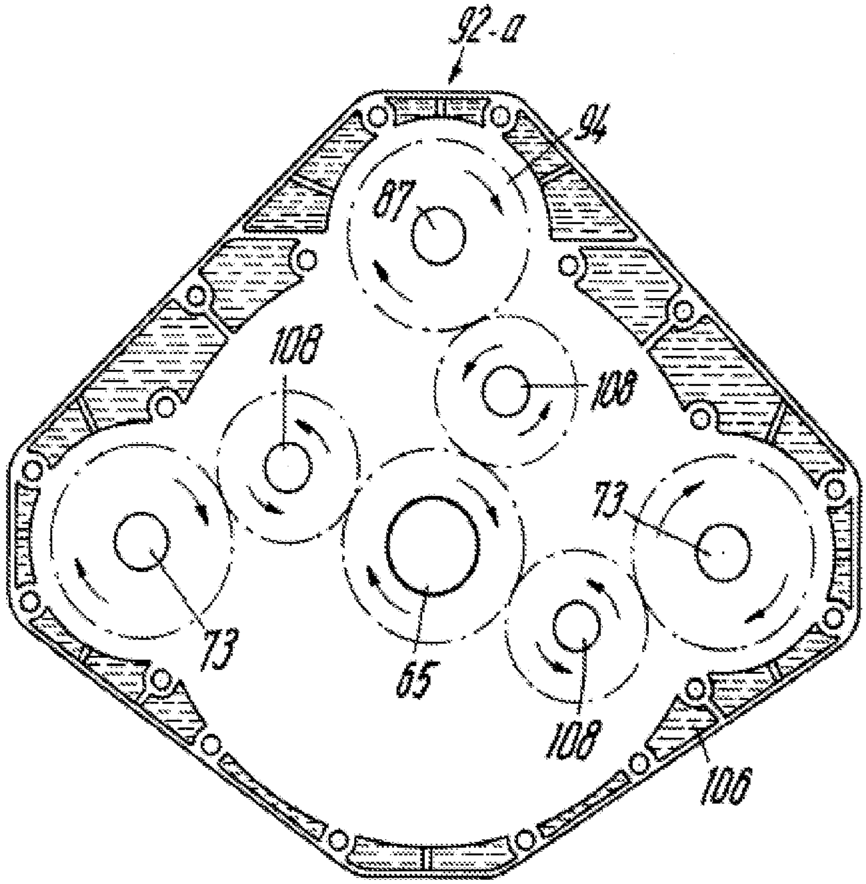


Fig. 26
(C-C)



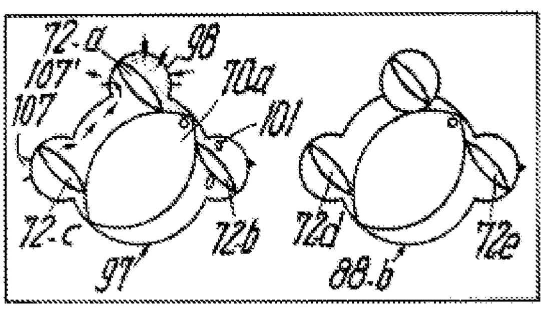


Fig. 27

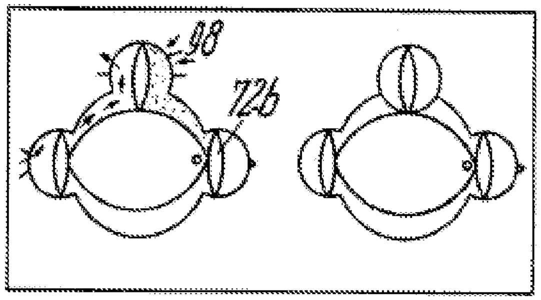


Fig. 28

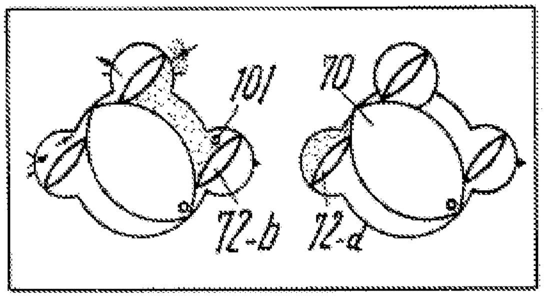


Fig. 29

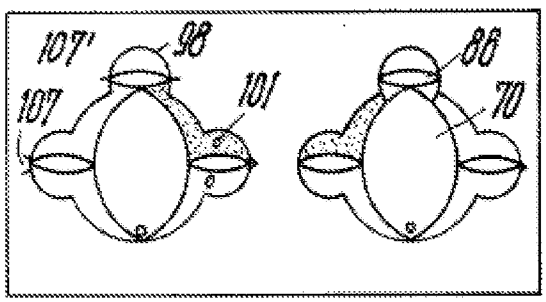


Fig. 30

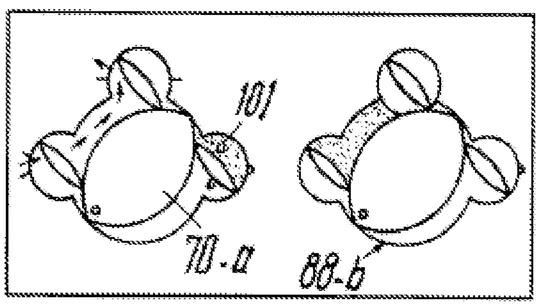


Fig. 31

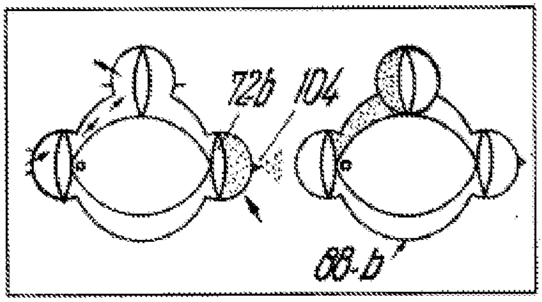


Fig.32

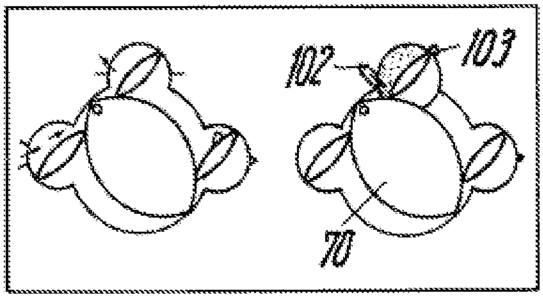


Fig.33

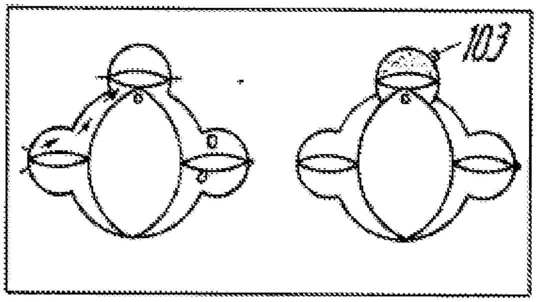


Fig.34

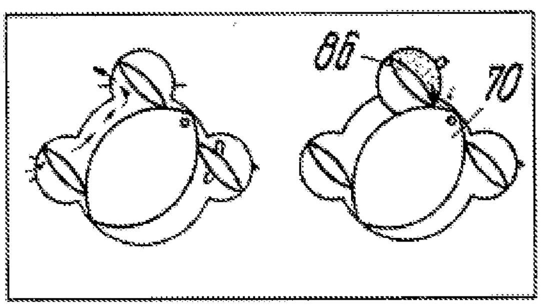


Fig.35

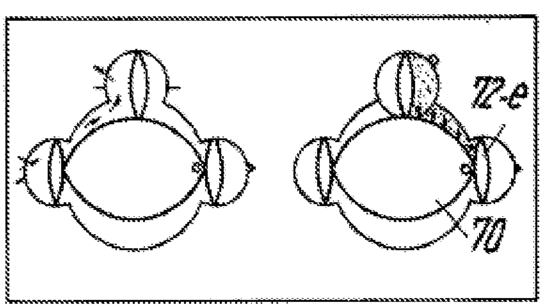


Fig.36

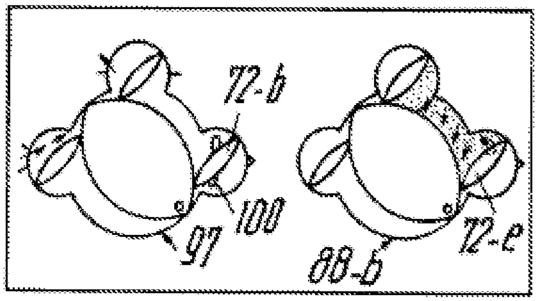


Fig. 37

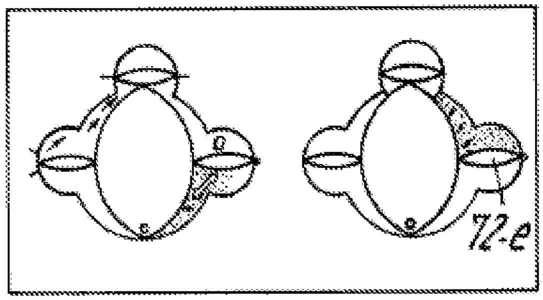


Fig. 38

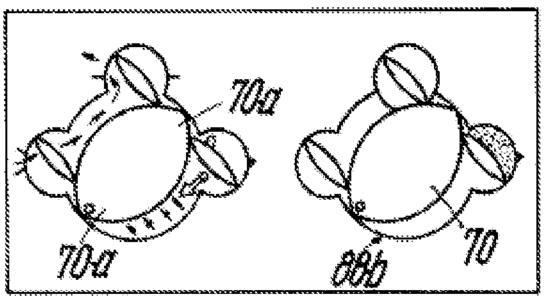


Fig. 39

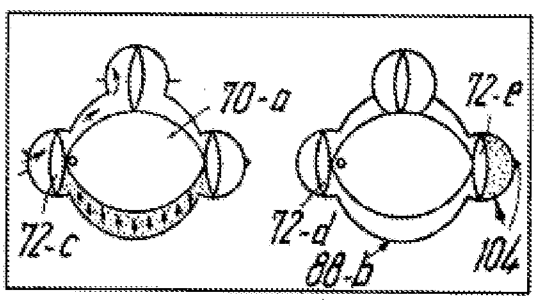


Fig. 40

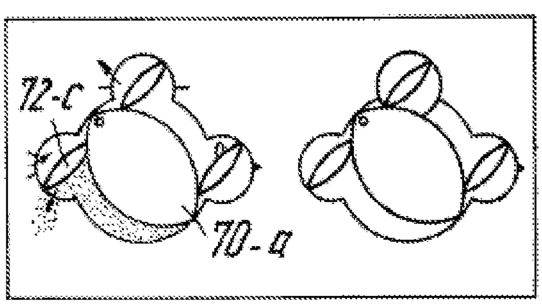


Fig. 41

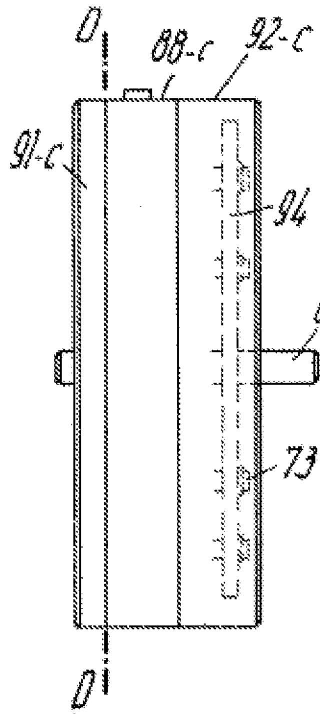
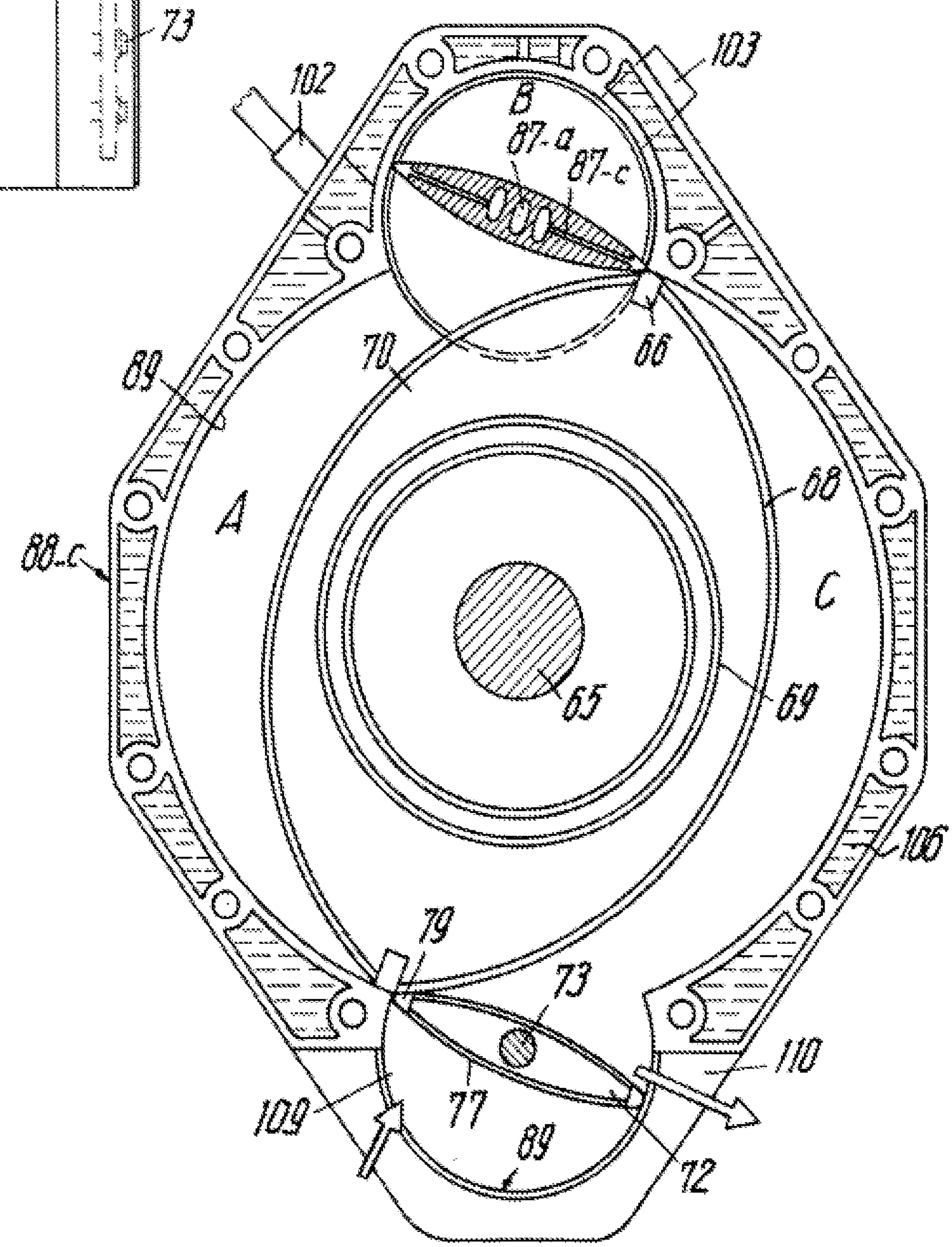


Fig.42

Fig.43
(D-D)



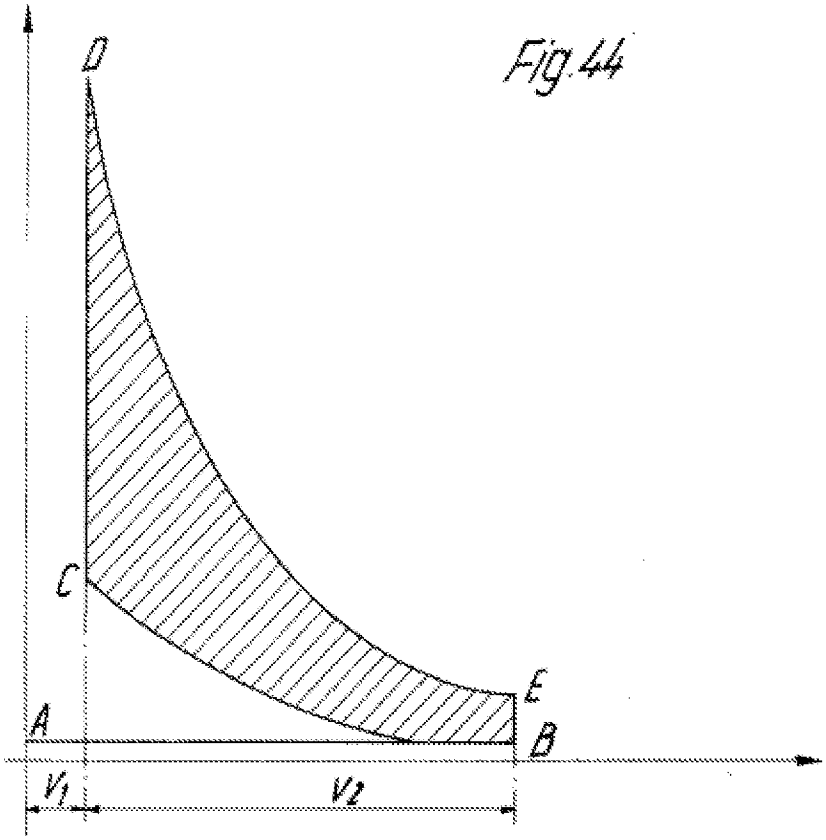


Fig.44

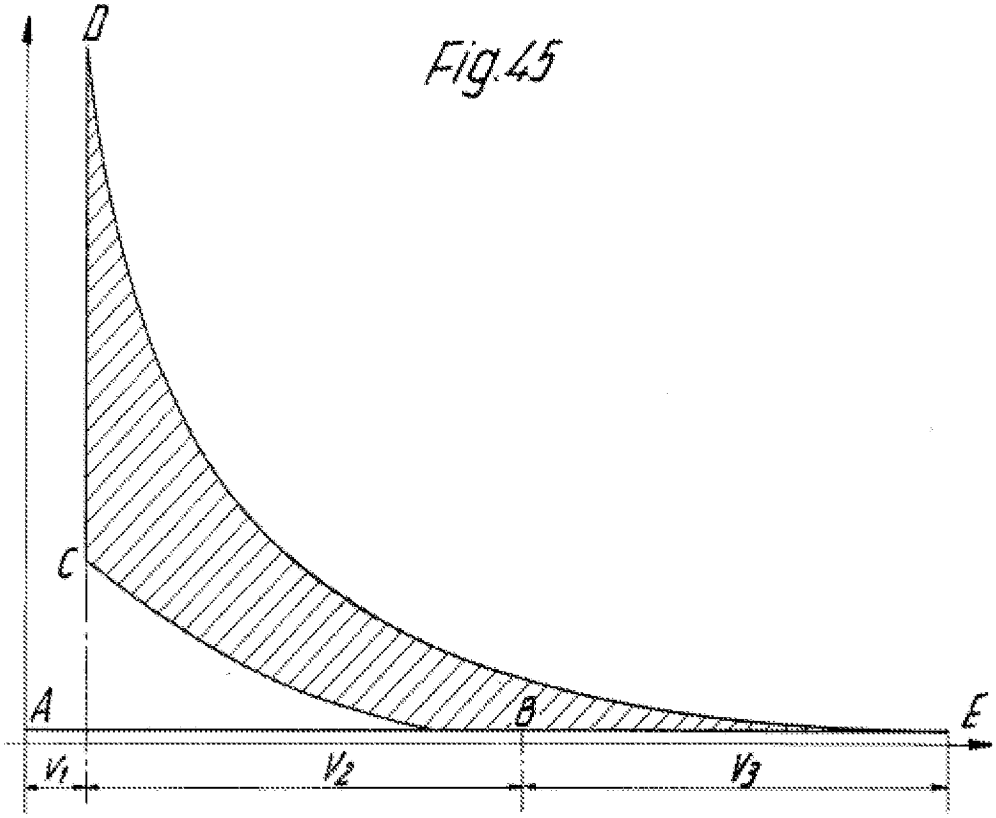


Fig.45

Fig. 46

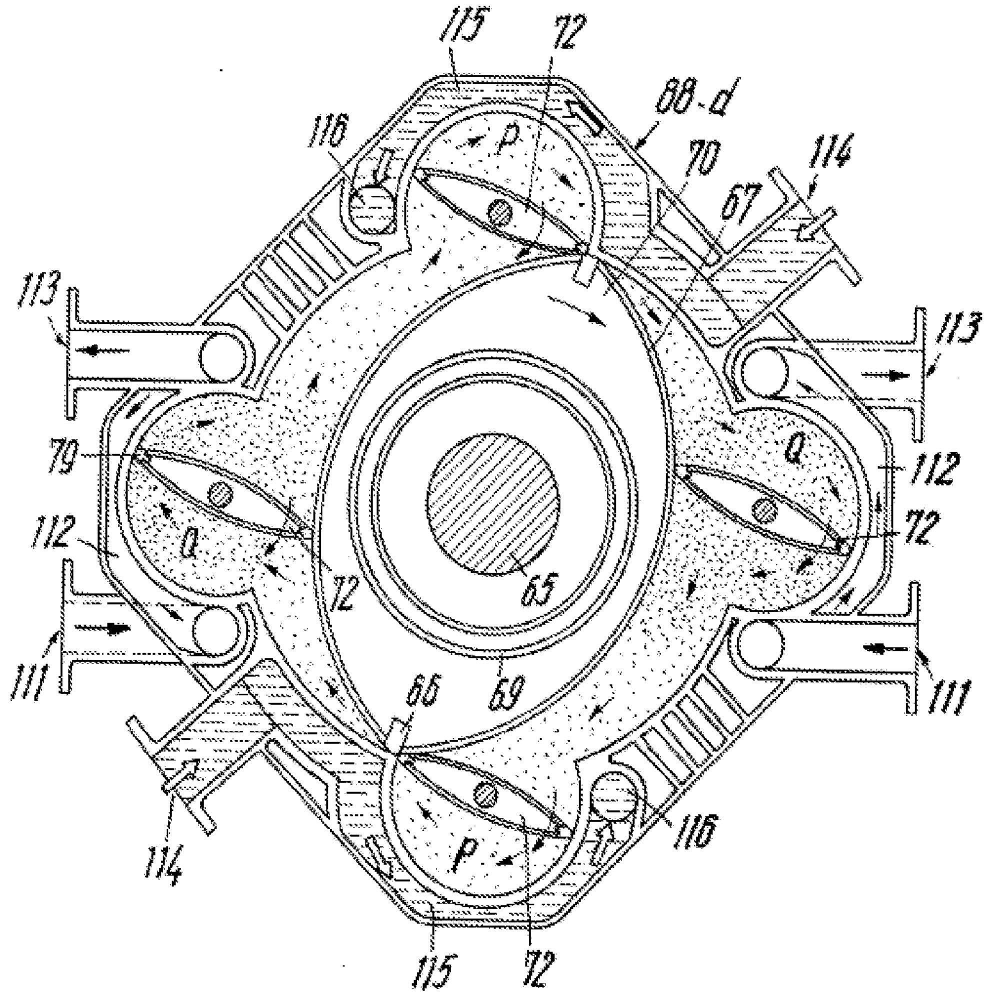

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Fig. 47

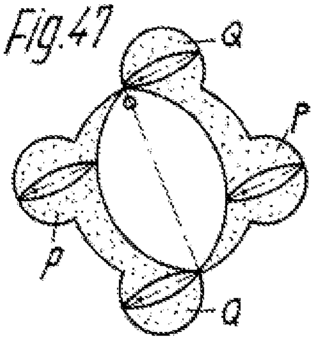


Fig. 48

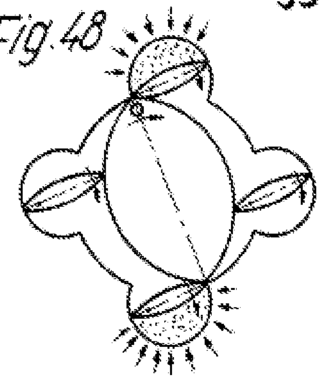


Fig. 49

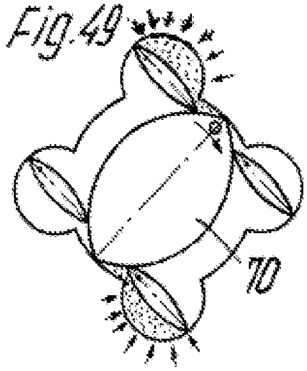


Fig. 50

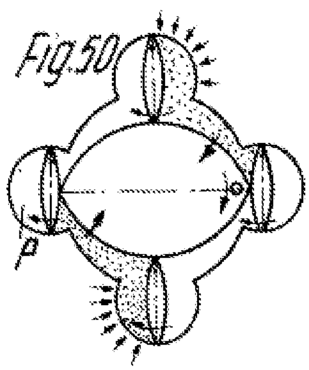


Fig. 51

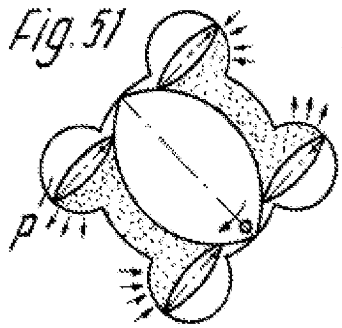


Fig. 52

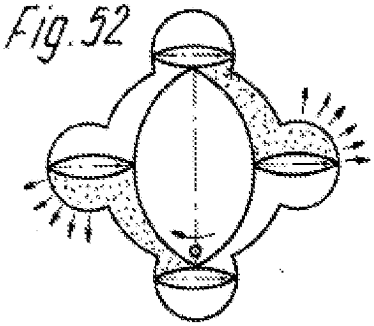


Fig. 53

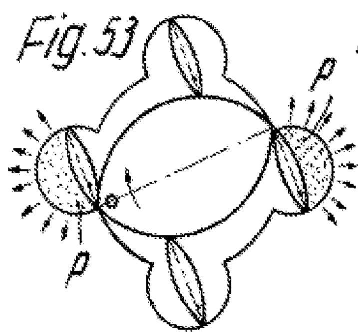


Fig. 54

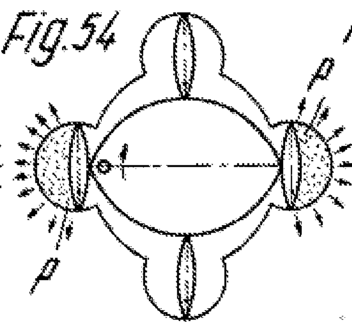


Fig. 55

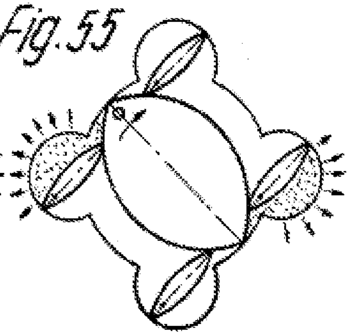


Fig. 56

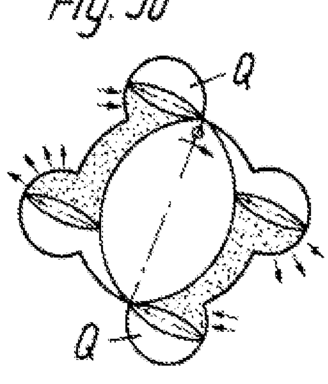


Fig. 57

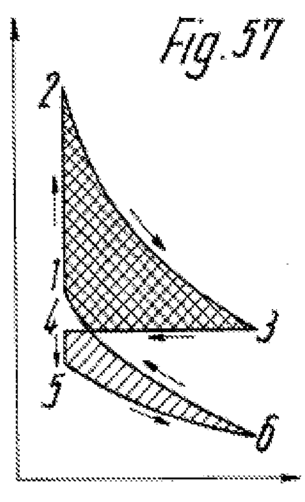


Fig. 58

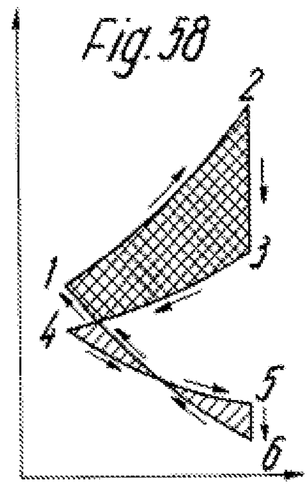


Fig.59

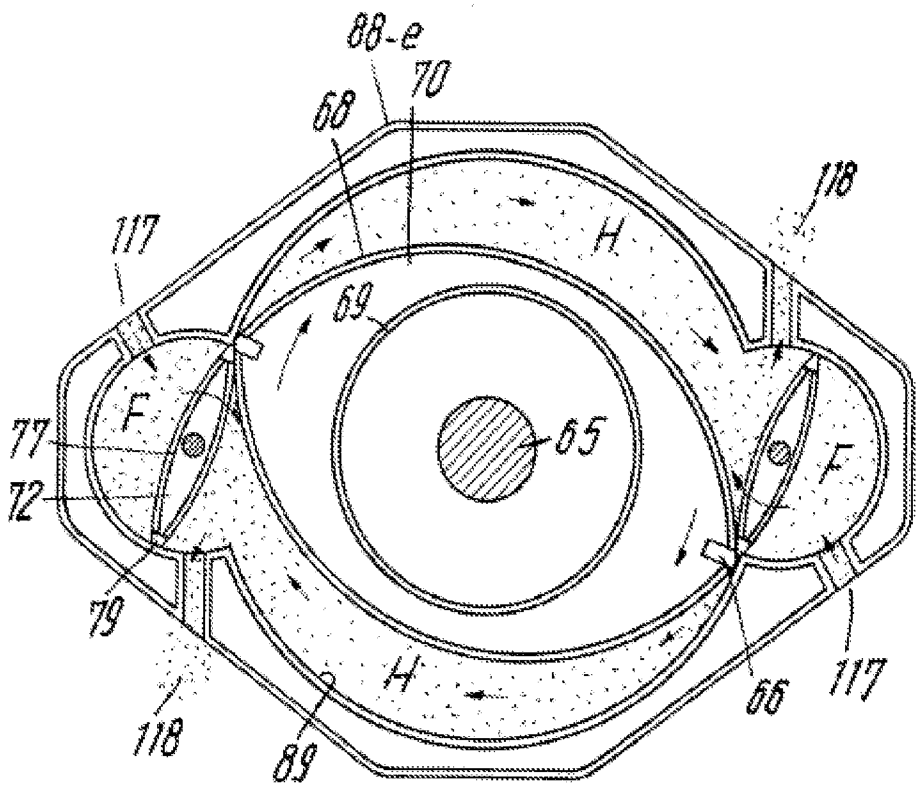


Fig. 59-a

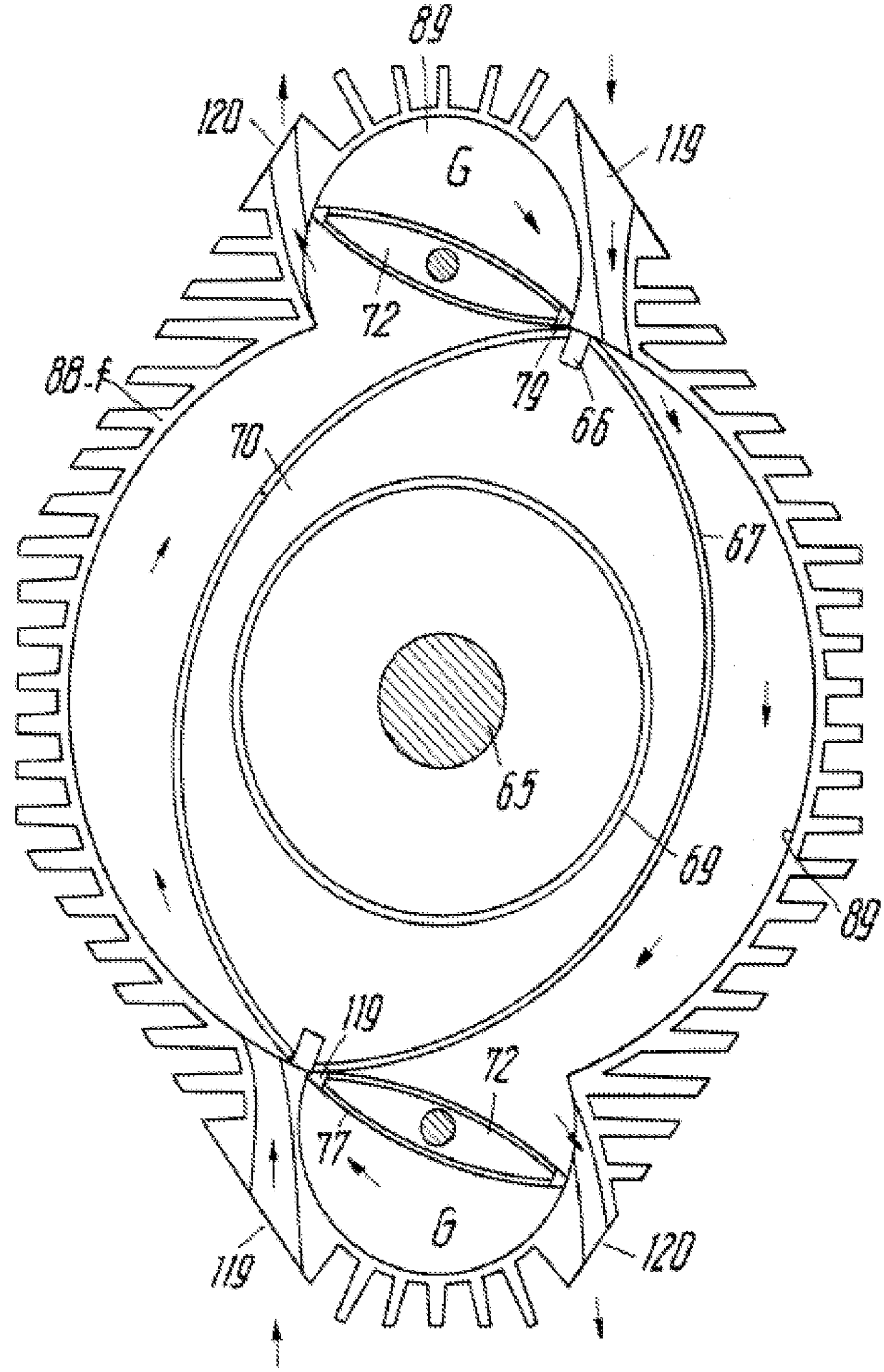


Fig. 60

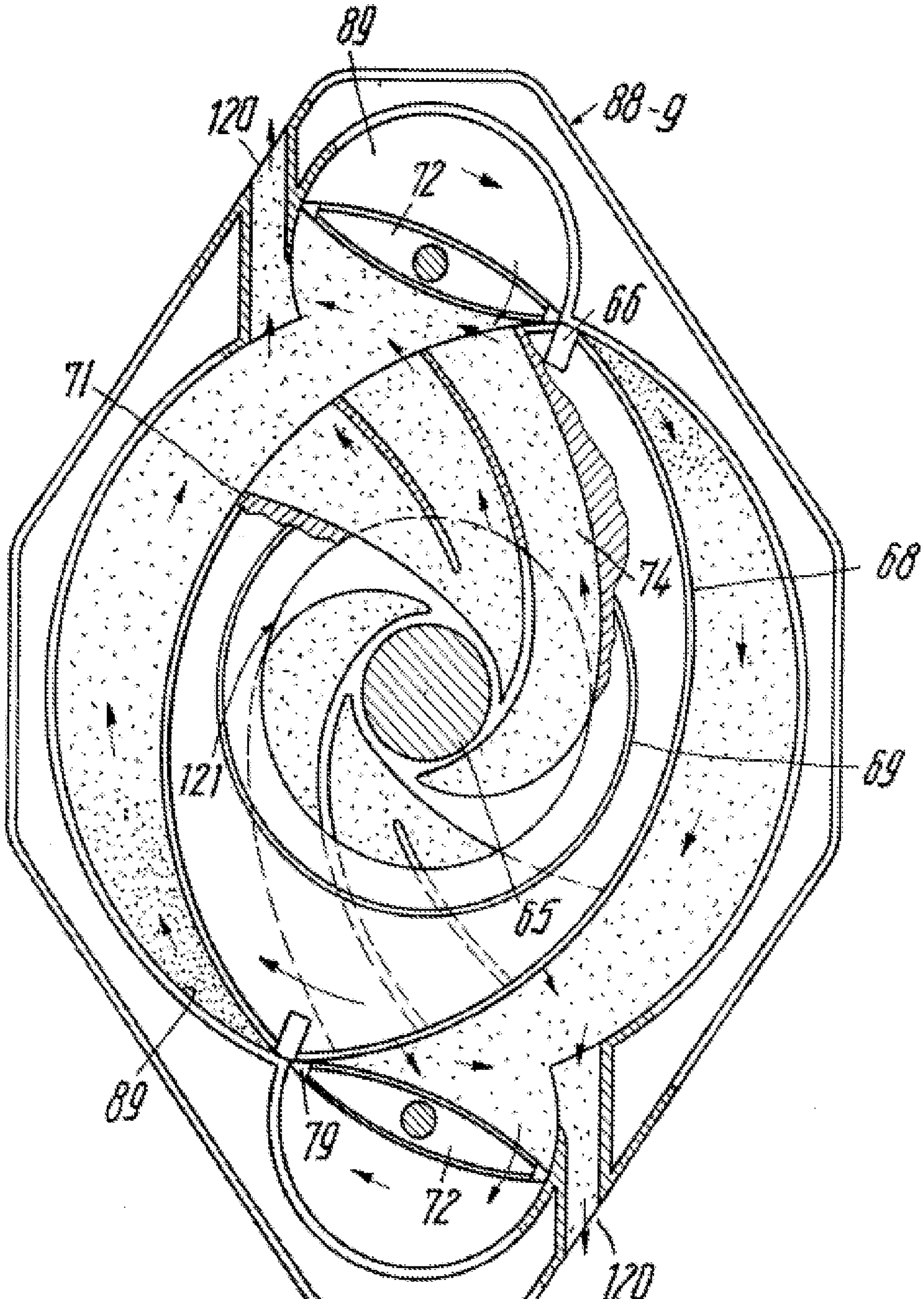


Fig. 60-a

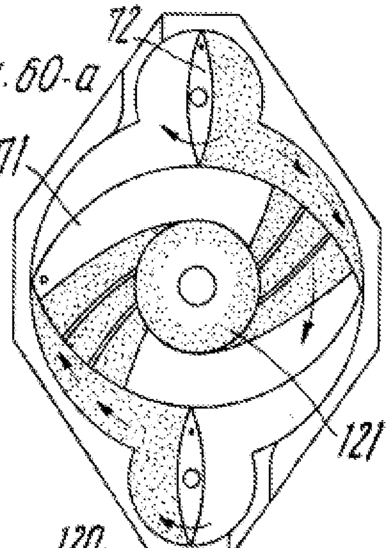


Fig. 60-b

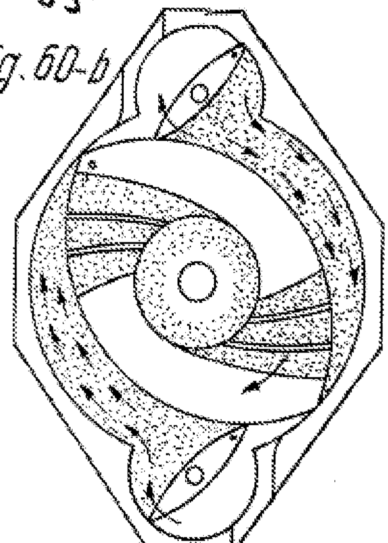


Fig. 60-c

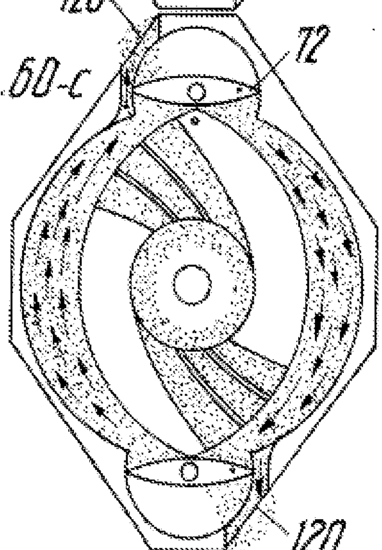


Fig. 60-d

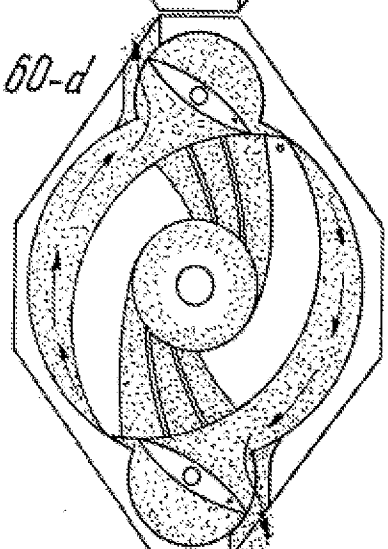


Fig. 60-e

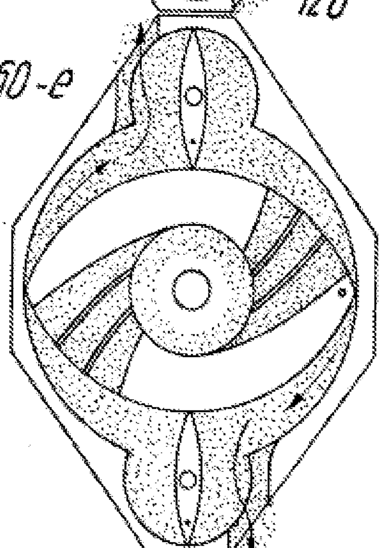


Fig. 60-f

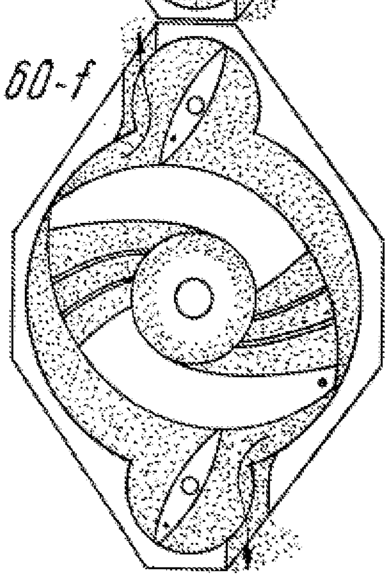
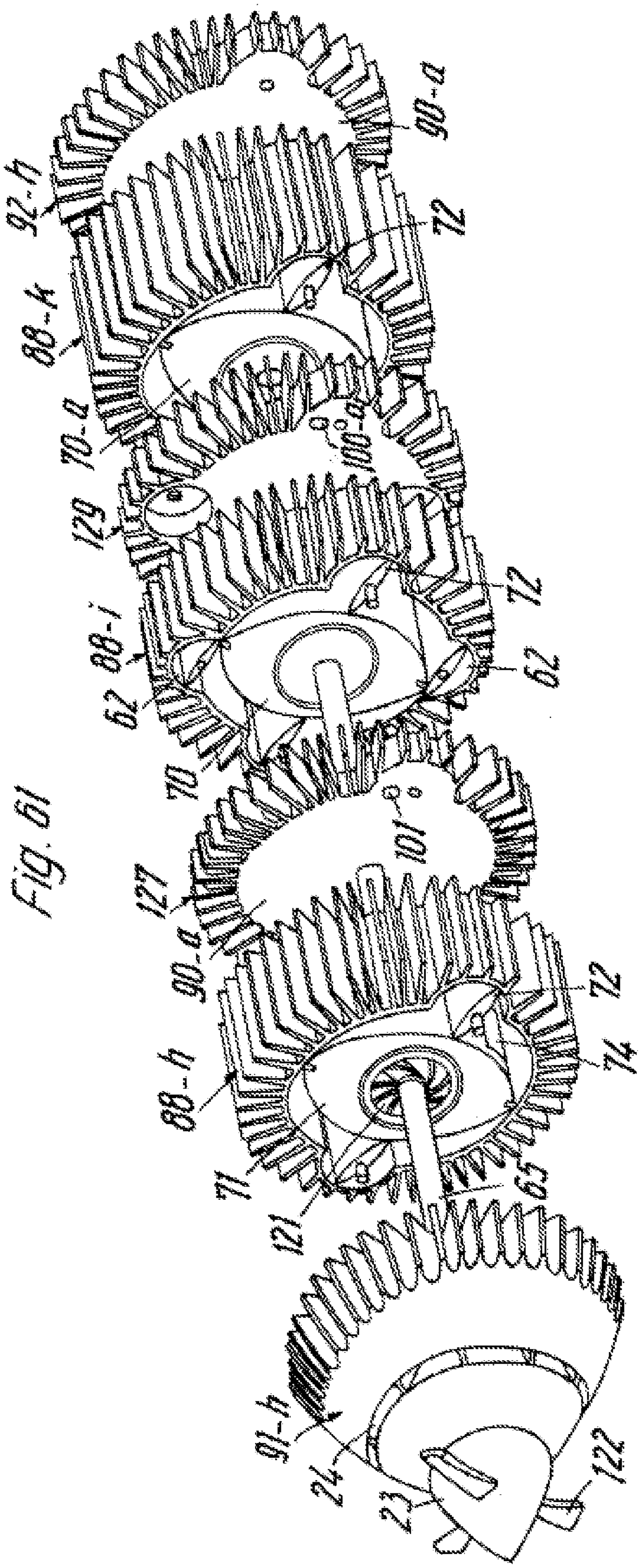


Fig. 61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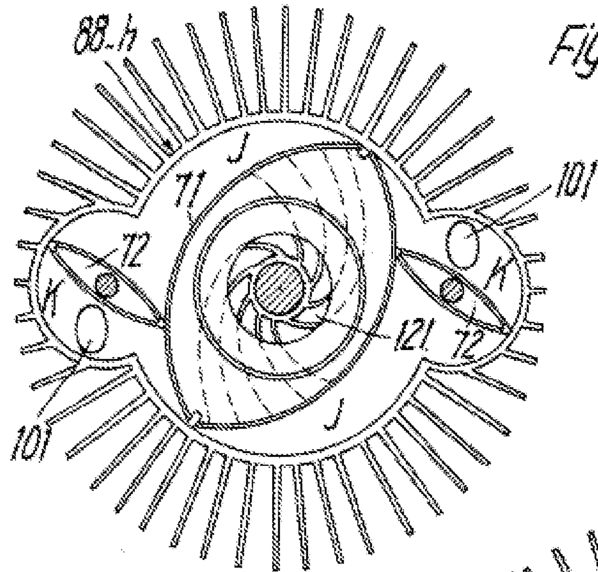

Fig. 61-a

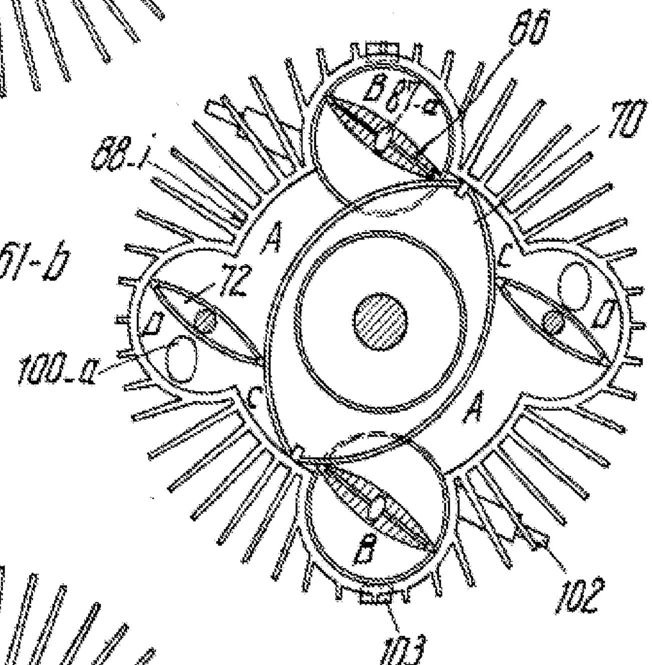

Fig. 61-b

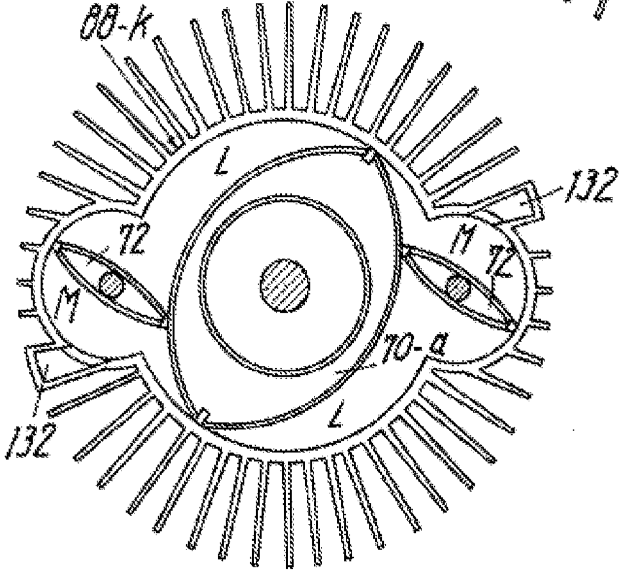

Fig. 61-c

Fig. 62

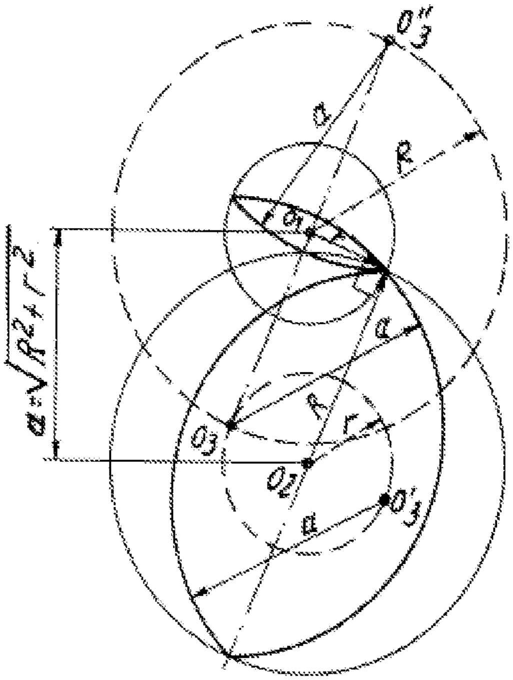

Fig. 62-a